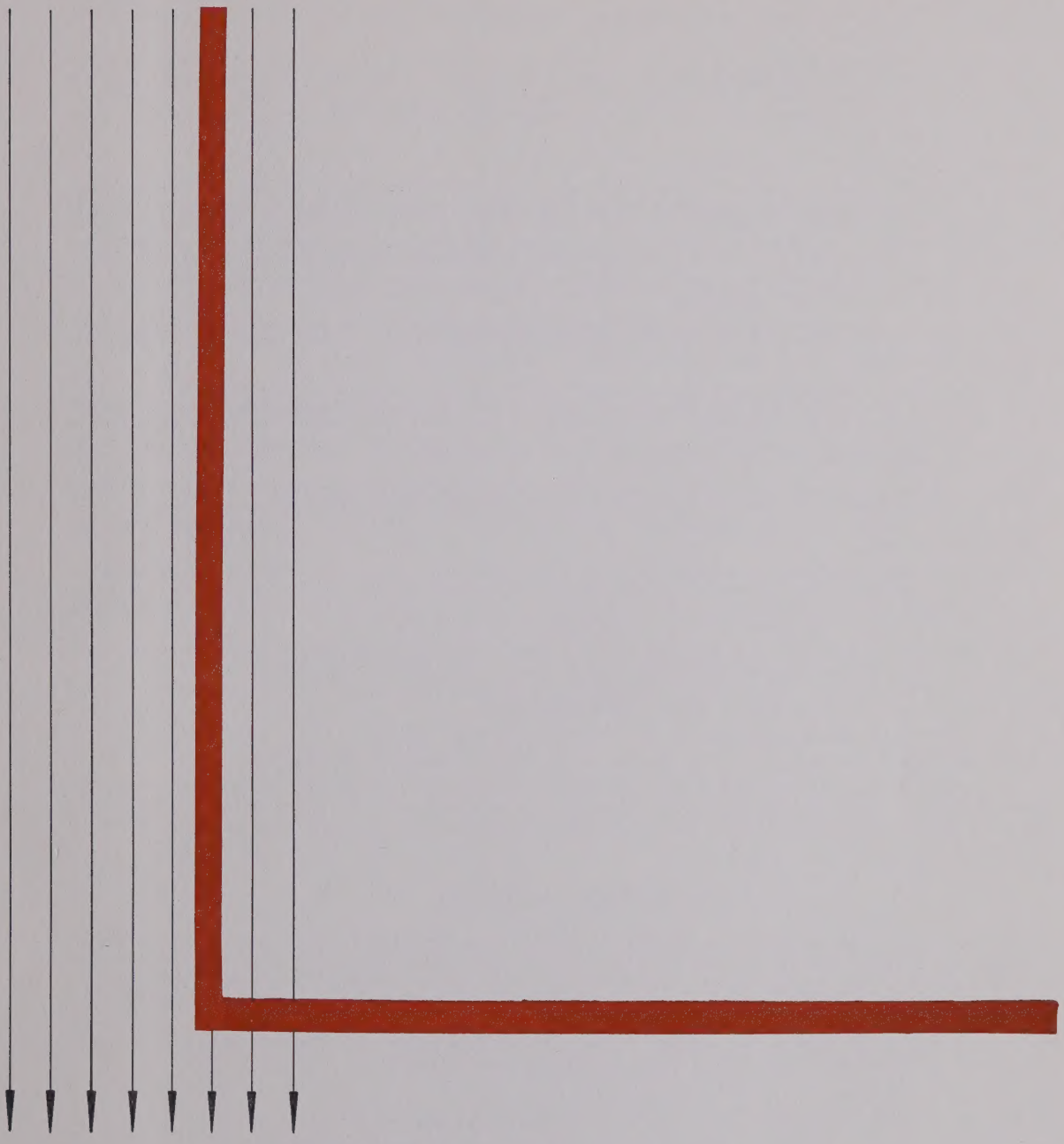
INSTRUCTION MANUAL

DATA STORAGE UNIT



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

November 1964

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

MANUAL REVISION

6100 Series
and
Models 601, 602, 607, 651, and 696

Design changes in the Model 6100 Series instruments have been made to accommodate a greater number of plug-in accessories. These changes have resulted in compatibility problems between current instruments, and instruments that were manufactured prior to the date of the change.

The chart on page 2 shows the combinations of counters and plug-ins that are compatible. If you have an incompatible combination, contact the factory. Indicate model, serial, and stock numbers of the instruments involved.

6100 SERIES COMPATIBILITY CHART

Plug-in Model	Stock No.	Counter Model No. 6147		6127		6146		6144		6126		6124		6120
		Stock No. 82-421406	82-416892	82-421405	82-418458	82-421404	82-413030	82-421402	82-413651	82-421403	82-413652	82-421401	82-413653	82-421469
601	82-421407	x	x	x	x	x	x			x	x			
	82-413654		x		x		x				x			
602	82-421408	x	x	x	x	x	x			x	x			
	82-413655		x		x		x				x			
607	82-421411	x	x	x	x	x	x			x	x			x
	82-412487		x		x		x				x			
651	82-421409	x	x	x	x	x	x	x	x	x	x	x	x	x
	82-413606		x		x		x		x		x		x	
695	82-420516	x	x	x	x	x	x	x	x	x	x	x	x	x
696	82-421410	x	x	x	x	x	x	x	x	x	x	x	x	x
	82-413050		x		x		x		x		x		x	
622	82-421715	x		x		x		x		x		x		x

NOTE: "x" indicates compatible combination.

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DIAGRAMS

Data Storage Unit Decoder Block	62-D-88
Data Storage Unit Schematic	D410532 - Rev. D
Data Storage Unit Component Layout	63-C-8

SECTION 1
INTRODUCTION

1.1 GENERAL

The Data Storage Unit (DSU) stores binary coded information received from a decimal counting unit (DCU) such as Beckman Model 850, 860, or 870, and displays this information on a separate electroluminescent readout. Upon command, the DSU converts binary information into a decimal equivalent. The DSU comprises a plug-in printed circuit board using all solid-state components.

1.2 SPECIFICATIONS

Table 1-1. Main Characteristics

COUNT DISPLAY	In-line digit on Sylvania Series NU-50 Electroluminescent panel (separate from DSU)
DISPLAY CONTROL OUTPUTS	Segment off: 50 volts p-p (typical) Segment on: 900 volts p-p (typical)
INPUT REQUIREMENTS (from DCU)	Binary "1" -6 volts Binary "0" -0.3 volts
CLEAR PULSE	-10 volts, 5 μs duration
SET PULSE	-10 volts, 5 μs duration
POWER REQUIREMENTS	B+ +105 volts at 10 ma +10 volts at 2 ma B- -15 volts at 23 ma Display 900 volts p-p, 500 cps
DIMENSIONS	6.56 inches by 4.09 inches
WEIGHT	5.3 oz.
MOUNTING	Two 15-pin P. C. Board Connectors

SECTION 2
OPERATION

2.1 INSTALLING THE DSU

The DSU plugs into two 15-pin printed card connectors.

2.2 INPUT REQUIREMENTS

Table 1-1 summarizes the input requirements of the DSU.

2.3 OUTPUT CHARACTERISTICS

2.3.1 Display Control Output

For each decimal digit (0 through 9) registered, a decoder in the DSU generates a combination of on/off voltages to control segments of a Sylvania series NU-50 electroluminescent display. Typical voltages are 50 volts peak-to-peak to extinguish a segment, and 900 volts peak-to-peak to light a segment.

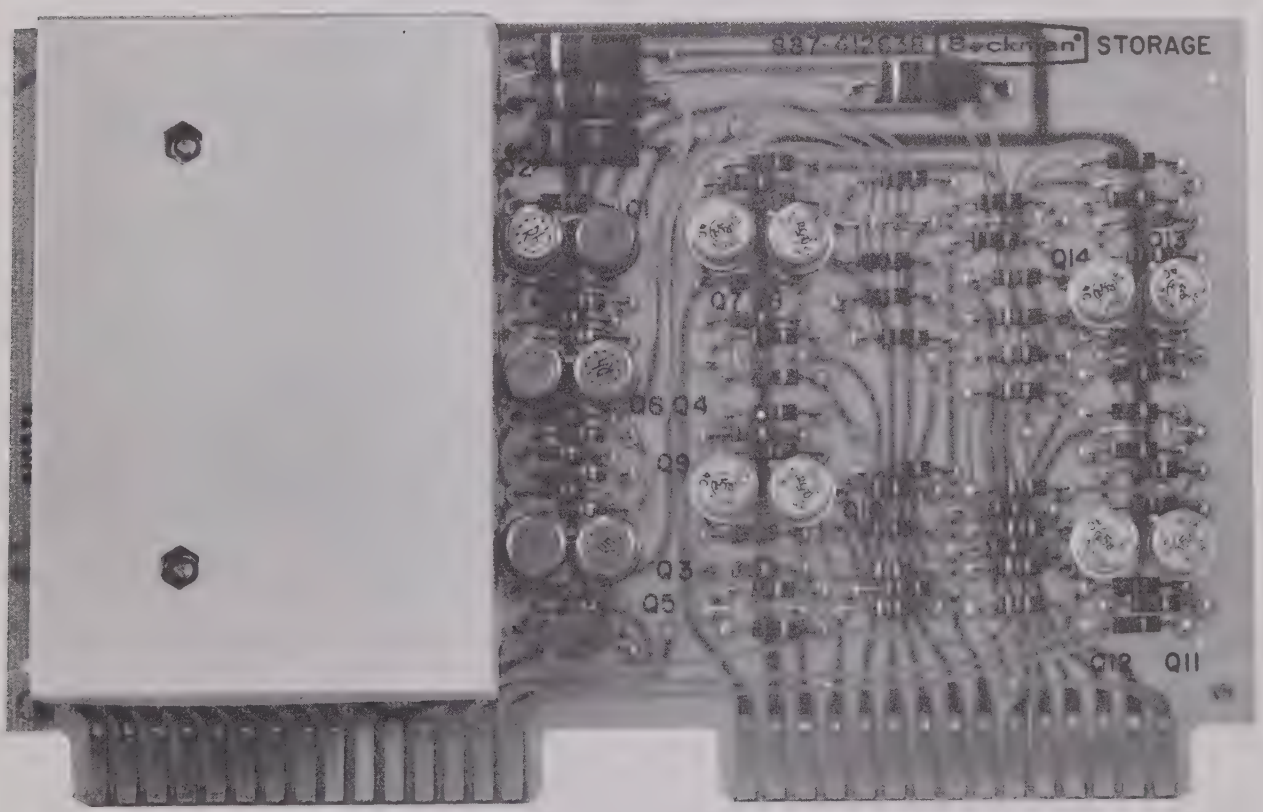


FIG. 2-1. Data Storage Unit Plug-in Printed Circuit Board

SECTION 3
CIRCUITS

3.1 BASIC CIRCUITS

As shown in Figure 3-1, the DSU comprises a storage and decoding circuit with a separate digital display. Section 3.2 describes the storage circuit, a set of four binary (flip-flop) stages. Section 3.3 explains how the decoding logic converts the stable states of the binaries into seven lines of display control information.

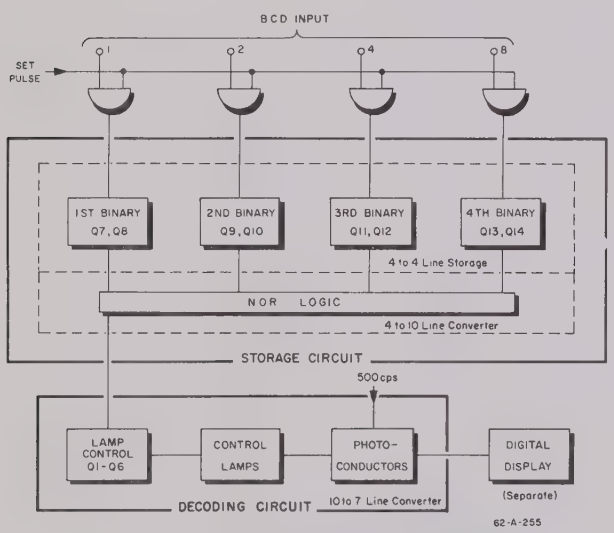


FIG. 3-1. Flow Diagram of Data Storage Unit

3.2 THE STORAGE CIRCUIT

Four binaries make up the storage circuit. Each binary comprises a pair of p-n-p transistors with the collector of each transistor directly coupled to the base of the other. Being symmetrical, the circuit can exist in either of two stable states: one transistor is cut off (OFF), and the other is conducting (ON).

In a p-n-p transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. Conversely, a positive base potential results in a high input impedance (several hundred thousand ohms); therefore, no base current flows and the transistor is cut OFF.

Figure 3-2 shows a typical binary in the "0", or clear, state (Q7 ON, Q8 OFF) and explains how the circuit stabilizes itself in that state.

With a negative voltage applied to the input terminal and a negative set pulse to R76, the binary changes states by a process described in Figure 3-3. During the change, the collector voltage of one transistor drops sharply while the other rises. These collector voltage swings drive transistors Q1-Q6 to provide the logic needed in converting the stable states of the four binaries into seven lines of display control information.

Driven by the storage binaries, transistors Q1-Q6 control the neon lamps. Depending on the ON-OFF combination of transistors Q1-Q6, neon lamps DS1 - DS15 light in appropriate combinations to provide the logic needed to control the electroluminescent segments.

Two conditions must exist before a neon lamp will light: enough potential to "fire" the lamp, and a complete current path. These two conditions are met by the ON-OFF combination of transistors Q1-Q6. Transistors Q3-Q6 act as switches to complete the current path for the lamps, while Q1 and Q2 set the potential for firing the correct lamps. Together, Q1-Q6 form the neon lamp control circuit.

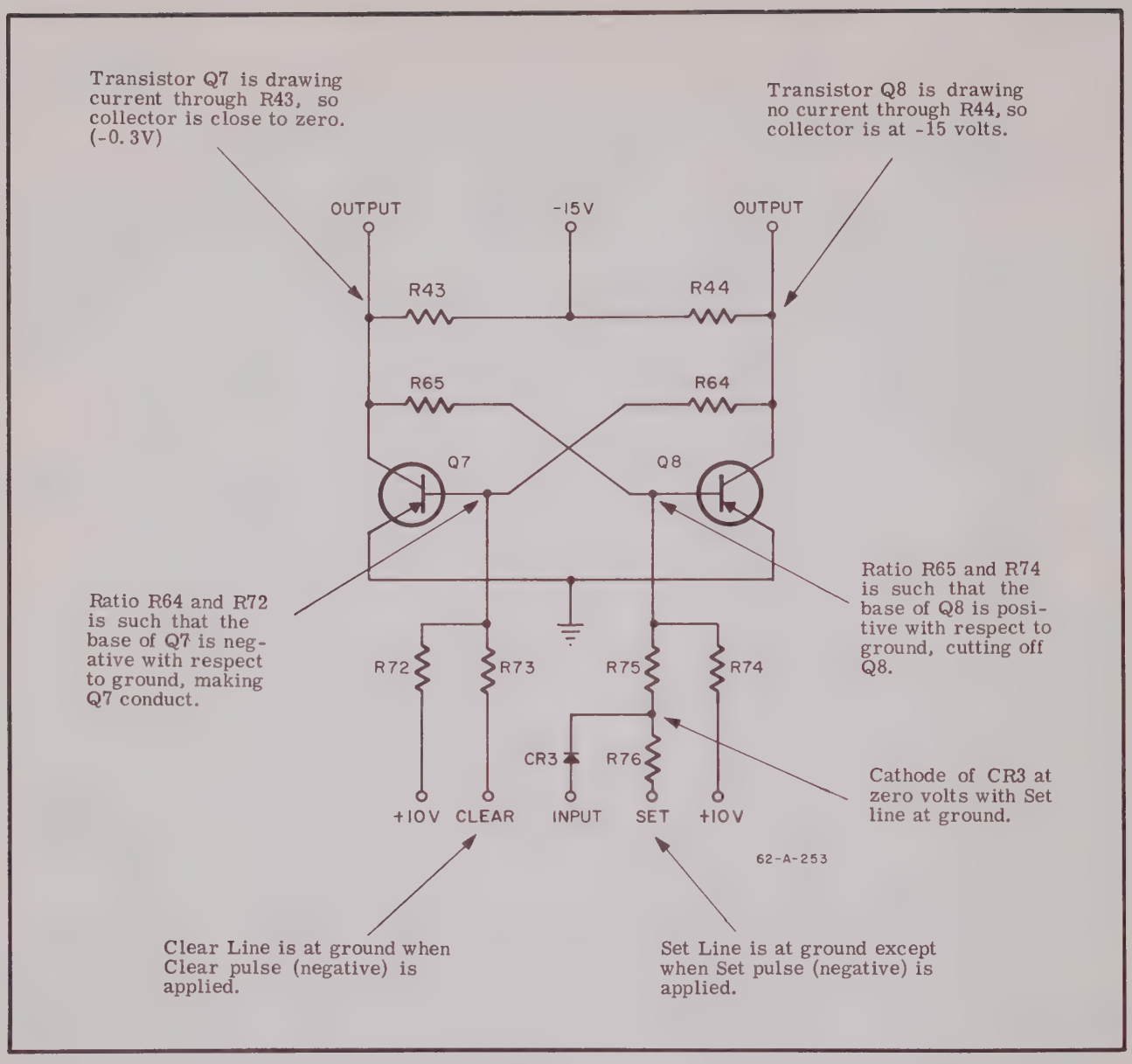

Transistor Q7 is drawing current through R43, so collector is close to zero. (-0.3V)
Transistor Q8 is drawing no current through R44, so collector is at -15 volts.
OUTPUT
-15V
OUTPUT
R43
R44
R65
R64
Q7
Q8
Ratio R64 and R72 is such that the base of Q7 is negative with respect to ground, making Q7 conduct.
Ratio R65 and R74 is such that the base of Q8 is positive with respect to ground, cutting off Q8.
R72
R73
R75
R74
CR3
R76
Cathode of CR3 at zero volts with Set line at ground.
+10V
CLEAR
INPUT
SET
+10V
62-A-253
Clear Line is at ground when Clear pulse (negative) is applied.
Set Line is at ground except when Set pulse (negative) is applied.

FIG. 3-2. A Typical Storage Binary in the "0" State

Figure 3-4 shows in simplified form the logic used to control the lamps. As shown, the storage binaries drive the lamp control circuits. When the storage binaries set, the lamp control transistors follow by either turning ON or OFF (Q1 normally ON, Q2-Q6 normally OFF in clear state).

The neon control circuits use n-p-n transistors instead of p-n-p transistors as in the storage binaries. Unlike the p-n-p transistor, the n-p-n transistor requires a positive voltage to turn it ON, and a negative voltage to turn if OFF. For example, assume these conditions exist using Figure 3-4 as a guide: Q2, Q3 and Q5 ON, Q1

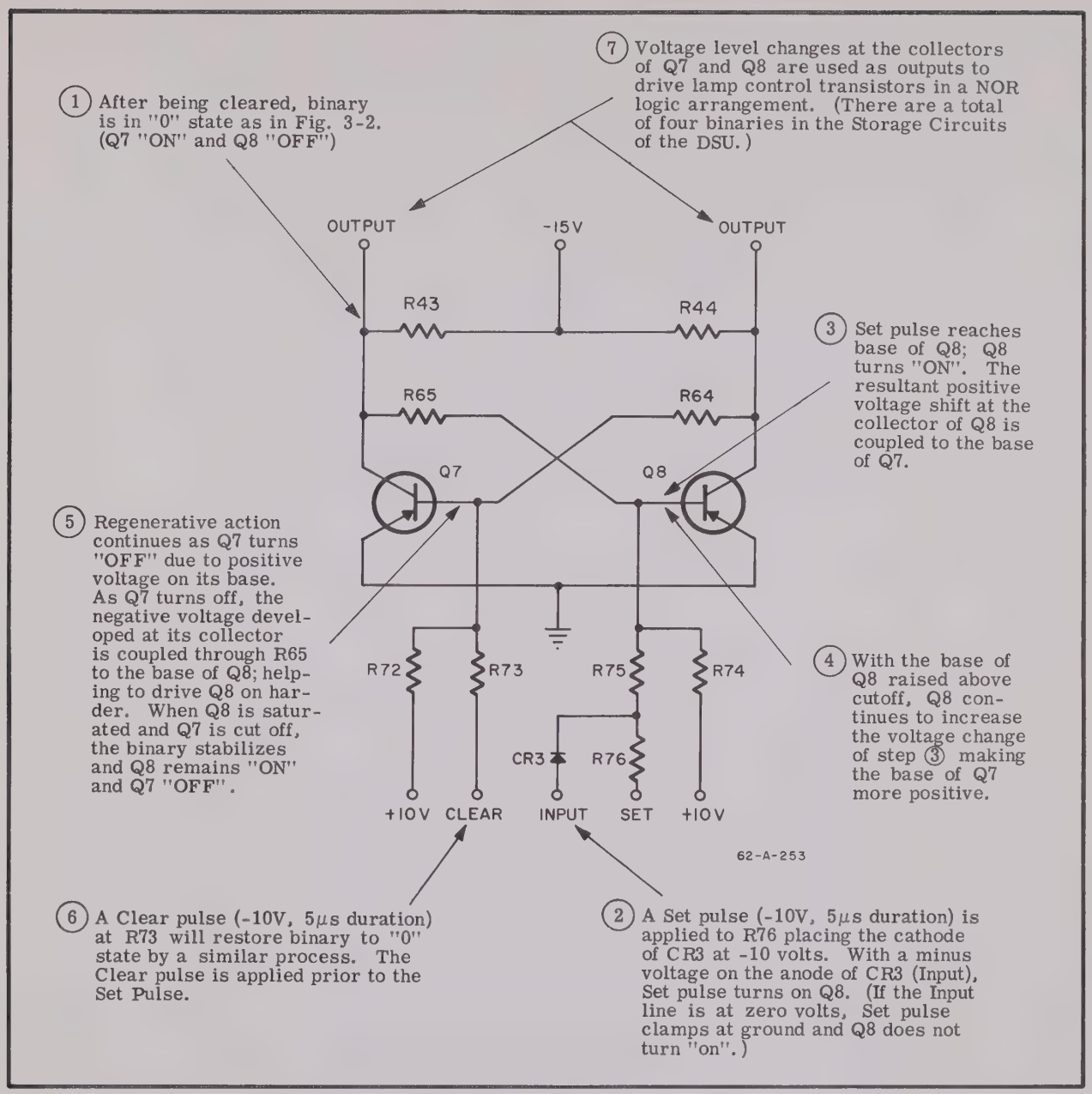

7 Voltage level changes at the collectors of Q7 and Q8 are used as outputs to drive lamp control transistors in a NOR logic arrangement. (There are a total of four binaries in the Storage Circuits of the DSU.)
1 After being cleared, binary is in "0" state as in Fig. 3-2. (Q7 "ON" and Q8 "OFF")
OUTPUT
-15V
OUTPUT
R43
R44
R65
R64
Q7
Q8
3 Set pulse reaches base of Q8; Q8 turns "ON". The resultant positive voltage shift at the collector of Q8 is coupled to the base of Q7.
5 Regenerative action continues as Q7 turns "OFF" due to positive voltage on its base. As Q7 turns off, the negative voltage developed at its collector is coupled through R65 to the base of Q8; helping to drive Q8 on harder. When Q8 is saturated and Q7 is cut off, the binary stabilizes and Q8 remains "ON" and Q7 "OFF".
R72
R73
R75
R74
CR3
R76
4 With the base of Q8 raised above cutoff, Q8 continues to increase the voltage change of step 3 making the base of Q7 more positive.
+10V
CLEAR
INPUT
SET
+10V
62-A-253
6 A Clear pulse (-10V, 5μs duration) at R73 will restore binary to "0" state by a similar process. The Clear pulse is applied prior to the Set Pulse.
2 A Set pulse (-10V, 5μs duration) is applied to R76 placing the cathode of CR3 at -10 volts. With a minus voltage on the anode of CR3 (Input), Set pulse turns on Q8. (If the Input line is at zero volts, Set pulse clamps at ground and Q8 does not turn "on".)

FIG. 3-3. Stages in the Transition of a Binary From the "0" State to the "1" State

OFF. With Q2 on, a voltage drop appears across R10 reducing the potential on DS1 and DS2 below the ignition point, even though Q3 is ON establishing a current path. But DS4 will fire since one side is tied to +110 volts and Q3 provides a current path.

Since Q1 is off, no voltage drop appears across R9. Lamps DS8 and DS9 can fire since Q5 is ON completing the current path. Note also that the collector of Q10 and the base of Q5 are tied together through R51 to form the NOR logic. If a positive voltage appears across R50 and turns

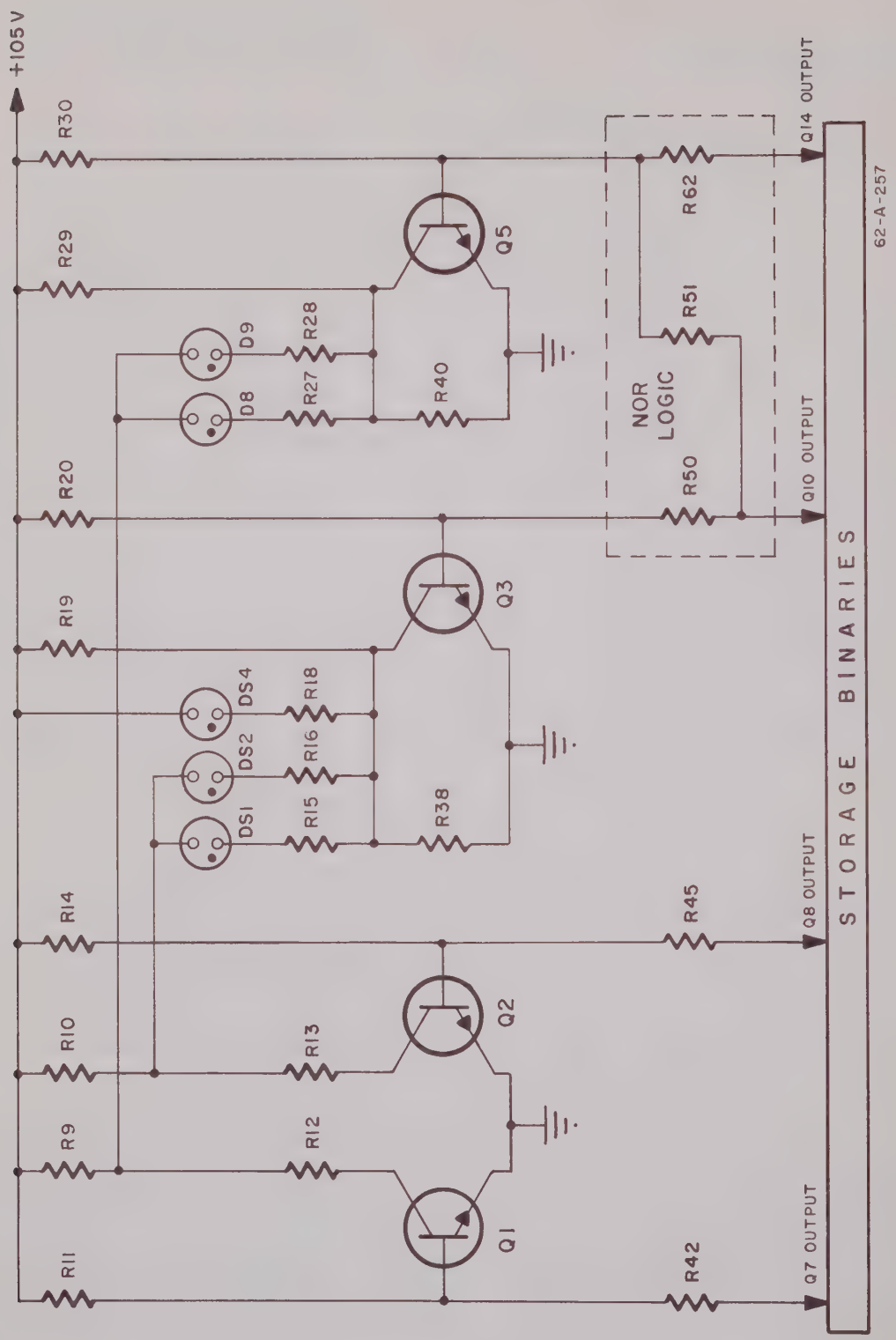


FIG. 3-4. Partial Schematic Indicating Lamp Control Logic

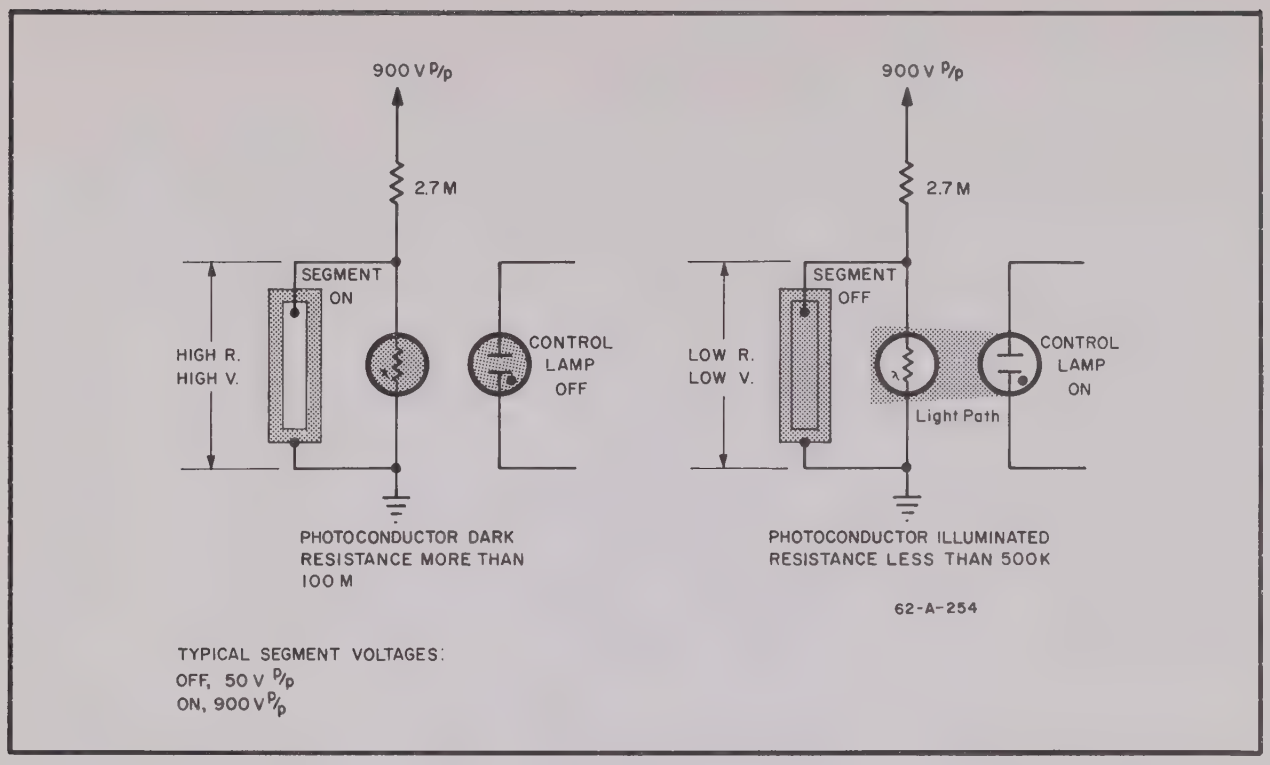


FIG. 3-5. The Basic Photoconductor Switching Circuit in Its Two States: Control Lamp "OFF", and Control Lamp "ON". "Low" and "High" are relative, not absolute, terms.

on Q3, but a negative voltage appears across R62 simultaneously, the negative voltage would override the positive voltage and turn Q3 and Q5 off. The schematic diagram shows in more detail the NOR logic that exists between the storage binaries and the lamp control transistors.

As described in Section 3.2, the storage circuit registers the decimal digits "0" through "9" as different voltage combinations on the collectors of the binaries. Using neon lamps, transistors, and photoconductors, the decoder converts the combinations into ON/OFF voltages controlling seven display segments on an electroluminescent panel.

Figure 3-5 shows the basic decoding circuit, which uses a photoconductor as the variable arm of a voltage divider. When the photoconductor is in total darkness, its internal resistance is more than 100 megohms. In the light of the neon "control" lamp, however, the resistance drops to less than 500K ohms. Thus, an electroluminescent segment connected across the photoconductor is switched on and off by the lamp.

The Decoder Block Schematic Diagram shows the complete decoder with its 16 control lamps. Lamp DS15 lights at all odd counts and turns off the lower segment (E) of the display. Lamp DS16 controls the decimal point (if one is used). Combinations of the other 14 lamps represent one registered count (0 through 9) and light at that count only.

Segment control is required for all digits except number 8. The lamps are enclosed with the photoconductors in a light-tight optical maze.

SECTION 4

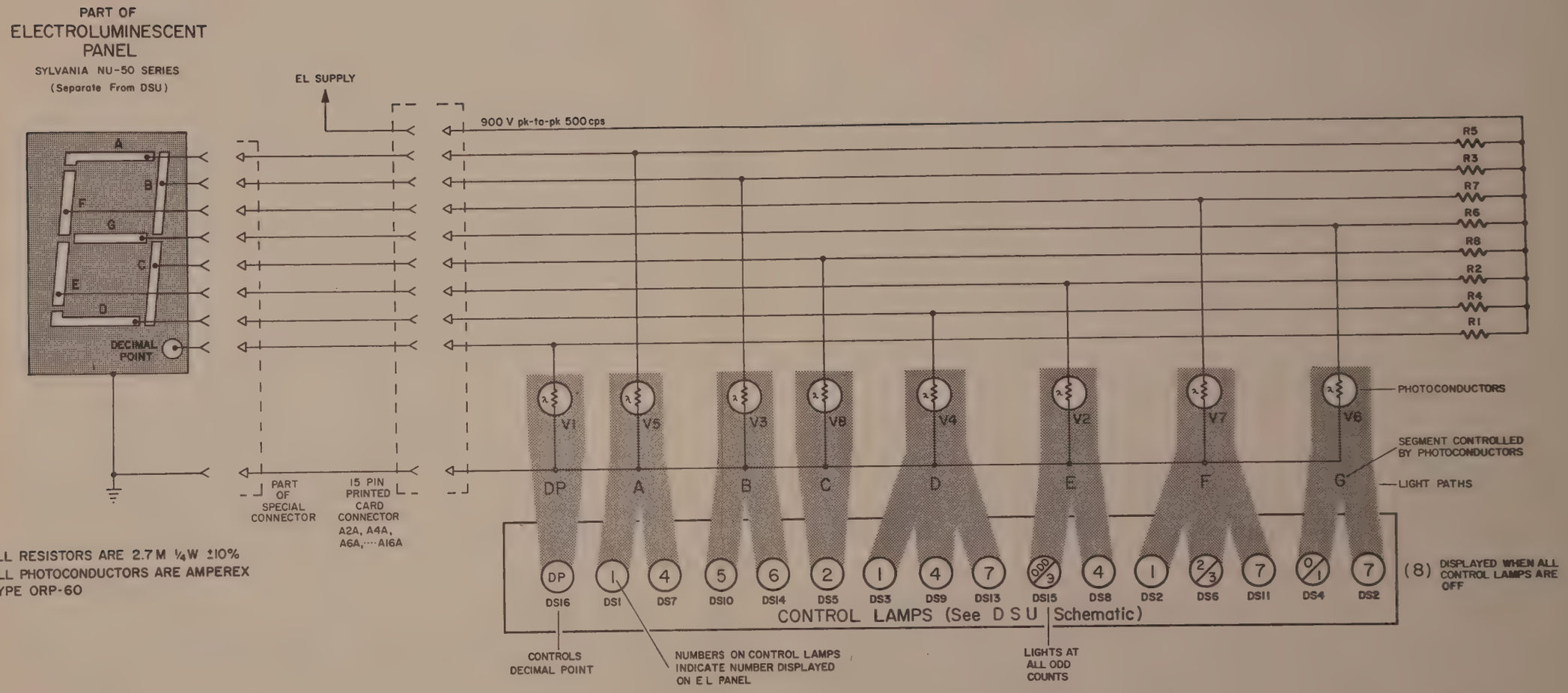
PARTS LIST

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
C1	633-804717	Capacitor, F. Cerm., 0.01 μf, 500V	Sprague 29C9B5	1
CR1 thru CR6	755-402107	Diode, Special, 1N95	Beckman/Berkeley	6
DS1 thru DS16	825-414955	Lamp, Neon	B/B	16
Q1 thru Q6	755-410066	Transistor, Silicon, NPN	B/B	6
Q7 thru Q14	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	Sylvania 2N404	8
R1 thru R8	601-824112	Resistor, F. Comp, 2.7M, 1/4W, 10%	Allen Bradley CB2751	8
R9 & R10	601-023764	Resistor, F. Comp, 3.9K, 1W, 5%	Allen Bradley	2
R11	601-823956	Resistor, F. Comp, 150K, 1/4W, 10%	Allen Bradley CB1541	2
R12 & R13	601-800065	Resistor, F. Comp, 3.3K, 1W, 5%	Allen Bradley	2
R14		Same as R11		
R15 thru R17	601-822798	Resistor, F. Comp, 68K, 1/4W, 5%	Allen Bradley	6
R18	601-822337	Resistor, F. Comp, 91K, 1/4W, 5%	Allen Bradley CB9135	3
R19	601-823959	Resistor, F. Comp, 330K, 1/4W, 10%	Allen Bradley CB3341	4
R20	601-823962	Resistor, F. Comp, 560K, 1/4W, 10%	Allen Bradley CB5641	4
R21	601-822543	Resistor, F. Comp, 82K, 1/4W, 5%	Allen Bradley CB8235	2
R22		Same as R18		
R23		Same as R19		
R24		Same as R20		
R25 thru R27		Same as R15		
R28	601-822543	Resistor, F. Comp, 82K, 1/4W, 5%	Allen Bradley	1
R29		Same as R19		
R30		Same as R20		
R31 thru R33		Same as R15		
R34		Same as R21		
R35		Same as R19		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R36		Same as R15		
R37		Same as R18		
R38 thru R41	601-823963	Resistor, F. Comp, 680K, 1/4W, 10%	Allen Bradley CB6841	4
R42	601-823108	Resistor, F. Comp, 10K, 1/4W, 10%	Allen Bradley CB1031	6
R43 & R44	601-823942	Resistor, F. Comp, 3.3K, 1/4W, 10%	Allen Bradley CB3321	8
R45		Same as R42		
R46 & R47	601-823950	Resistor, F. Comp, 39K, 1/4W, 10%	Allen Bradley CB3931	12
R48 & R49		Same as R43		
R50 thru R53		Same as R46		
R54 & R55		Same as R43		
R56 & R57		Same as R46		
R58 & R59		Same as R43		
R60 thru R63		Same as R46		
R64 thru R71	601-822333	Resistor, F. Comp, 12K, 1/4W, 5%	Allen Bradley CB1235	8
R72	601-823109	Resistor, F. Comp, 33K, 1/4W, 10%	Allen Bradley CB3331	8
R73		Same as R42		
R74		Same as R72		
R75	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	Allen Bradley CB4721	4
R76	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 10%	Allen Bradley CB5621	4
R77		Same as R42		
R78 & R79		Same as R72		
R80		Same as R75		
R81		Same as R76		
R82		Same as R42		
R83 & R84		Same as R72		
R85		Same as R75		
R86		Same as R76		
R87		Same as R42		
R88 & R89		Same as R72		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R90		Same as R75		
R91		Same as R76		
R92		Same as R20		
V1 thru V8	753-416278	Photo-Resistor, END-View, Special	B/B	8
	864-412958	Pad, Connector, Transistor	B/B	14
	824-412922	Lamp Block, Base	B/B	1
	824-414475	Lamp Block, Cover	B/B	1

DSU DECODER BLOCK DIAGRAM 34



NOTES:
(1) ALL RESISTORS ARE 2.7 M ¼W ±10%
(2) ALL PHOTOCONDUCTORS ARE AMPEREX TYPE ORP-60

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62-D-88
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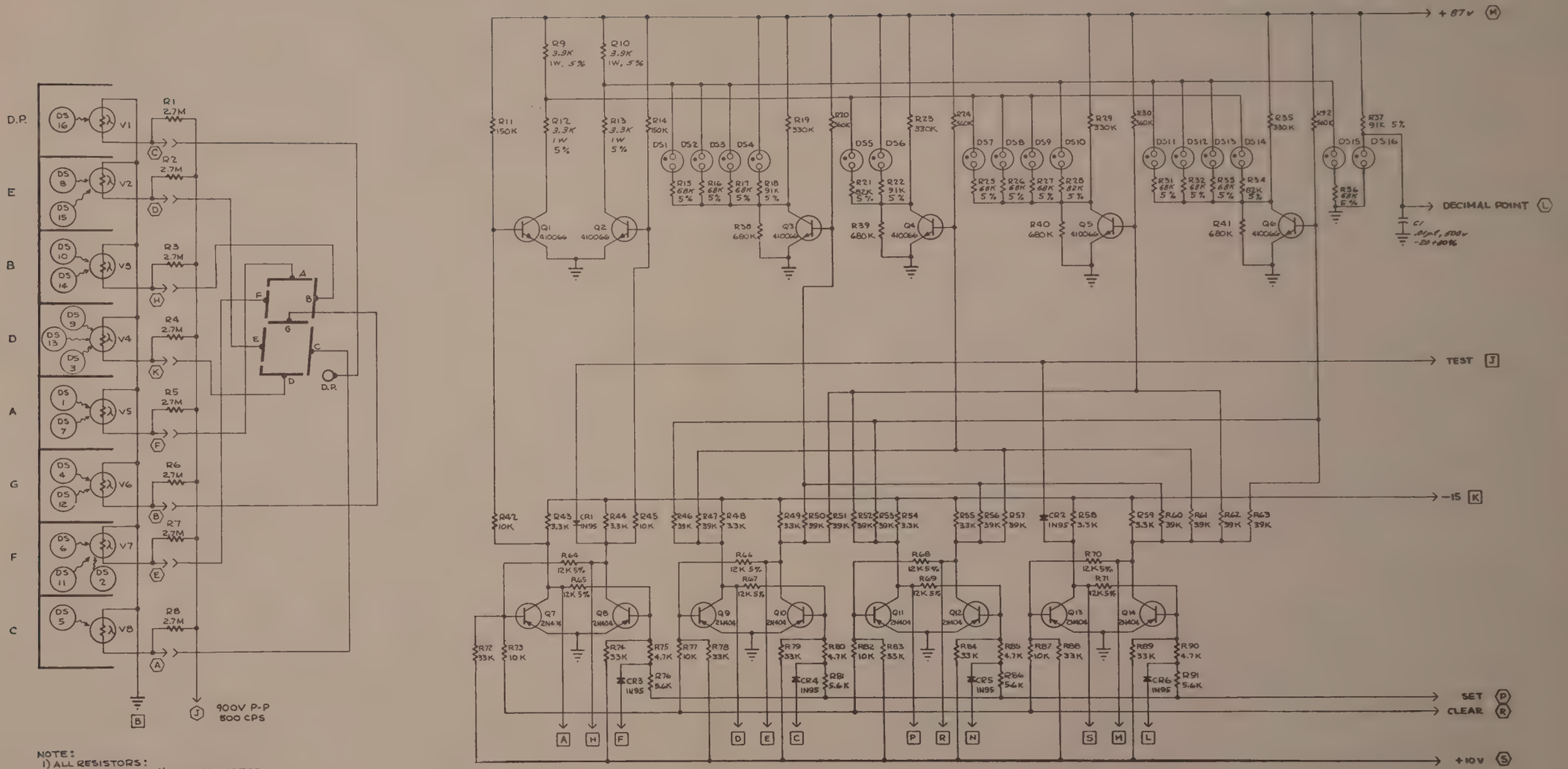


NOTE:
1) ALL RESISTORS:
WATTAGE — 1/4 W UNLESS NOTED
TOLERANCE — 10% UNLESS NOTED

2) ⬡ — INDICATES PINS OF P1 (FRONT CONNECTOR)

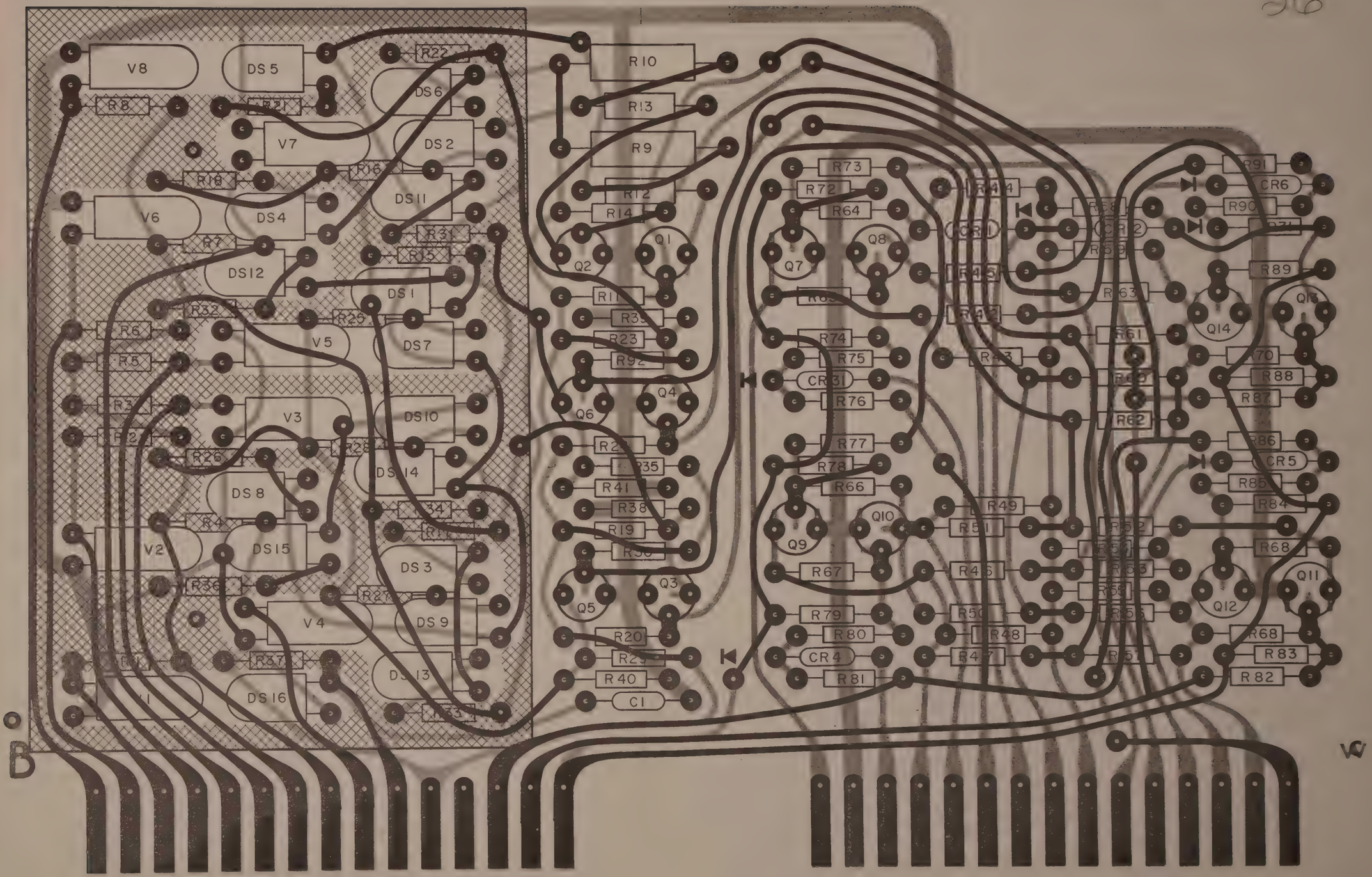
3) □ — " " " P2 (REAR CONNECTOR)

4) ALL PHOTORESISTORS (V1 THRU V8) ARE TO BECKMAN SPEC., DWG. 383-416878.

5) ALL NEON LAMPS (DS1 THRU DS16) ARE TO BECKMAN SPEC., DWG. 825-414555.

Data Storage Unit
D410532 Rev. D
October 1963
Beckman

DATA STORAGE UNIT COMPONENT LAYOUT



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ME-1488

MODEL 6147
ADDENDUM

Section 3 — Theory of Operation
and
Section 4 — Servicing

70-04-13-50

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August 1968

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(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company nameplate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Electronic Instruments Division of Beckman Instruments, Inc., Richmond, California, 94804.

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Experienced service personnel and special test equipment are available at any of three Regional Service Centers and the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. To obtain warranty service contact your nearest Beckman Service Office, which will give you the necessary instructions for returning the instrument. Beckman Service Offices now in operation are shown on the bottom of this sheet. Instruments returned for service will be sent to the Beckman Service Office, transportation charges prepaid. The instrument will be returned to the purchaser with transportation charges prepaid.

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SECTION 3
THEORY OF OPERATION

3.1 GENERAL

This section describes the operating theory of the Model 6147.

As shown in Figure 3-1, Model 6147 consists of two input circuits (paragraph 3.3), a time base generator (paragraph 3.4), a signal gate and control circuit (paragraph 3.5), a recycle circuit (paragraph 3.6), a chain of decimal counting units (DCU's), and data storage units (DSU's) with an electroluminescent (EL) display. These major circuits are interconnected with logic gates (paragraph 3.2) which are controlled by the TIME and MODE selectors.

The power supplies are described in paragraph 3.8, and the Legend in paragraph in paragraph 3.7. Basic circuits are covered in paragraph 3.9. An overall block diagram is given at the end of Section 3, and should be referred to in the following discussions. Individual schematic diagrams should also be used.

Measurements are made by comparing the unknown input signal with an internal time base of known accuracy. When measuring frequency (E/UT X) for example, the signal gate opens and closes at a rate determined by the setting of the TIME selector. While the gate is open, pulses representing the input frequency are fed from the input circuit (INPUT X) through the gate to the count DCU's.

The accumulated count in the DCU's transfers to the DSU's at the end of a counting period (in LATCH), and is displayed on the EL panel. In FOLLOW, the DSU's

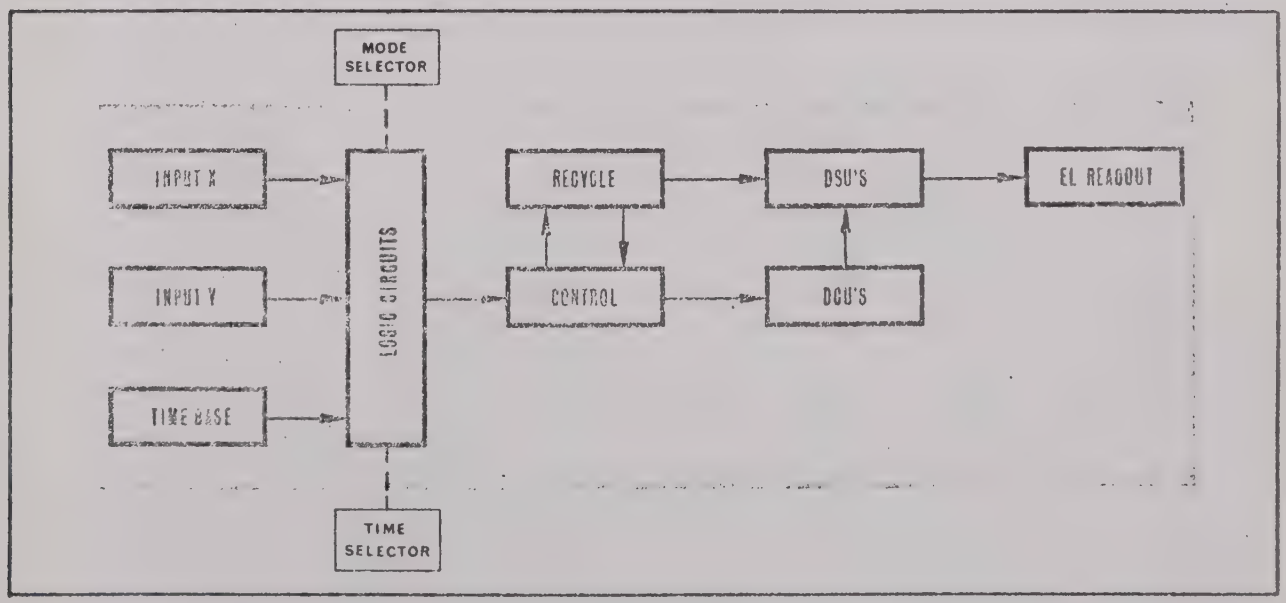


FIG. 3-1. Simplified Block Diagram.

follow the progression of the count DCU's and the EL panel displays count information as it is being accumulated.

3.2 LOGIC CIRCUITS

Logic circuits switch and interconnect signal paths between major sections to perform the measurement indicated on the front panel. The logic circuits consist of diode AND gates which have their bias controlled by the TIME, MODE, and SLOPE controls. When a diode is reverse-biased, the gate is closed. Conversely, if a diode is forward-biased, the gate is open. Figures 3-2A and 3-2B, respectively, show a typical logic gate in the closed and open states.

As shown in Figure 3-2A, positive pulses at C1 have insufficient amplitude to overcome the reverse bias on diode CR1, and there is no output. In Figure 3-2B, S1 removes the reverse bias by effectively clamping the junction of R1 and CR1 to near ground potential. Positive pulses at C1 then pass through CR1 to the output.

Another configuration of the logic circuit is shown in Figure 3-3. In this circuit, CR2 replaces R2, but operation is identical to the circuits shown in Figure 3-2A and 3-2B.

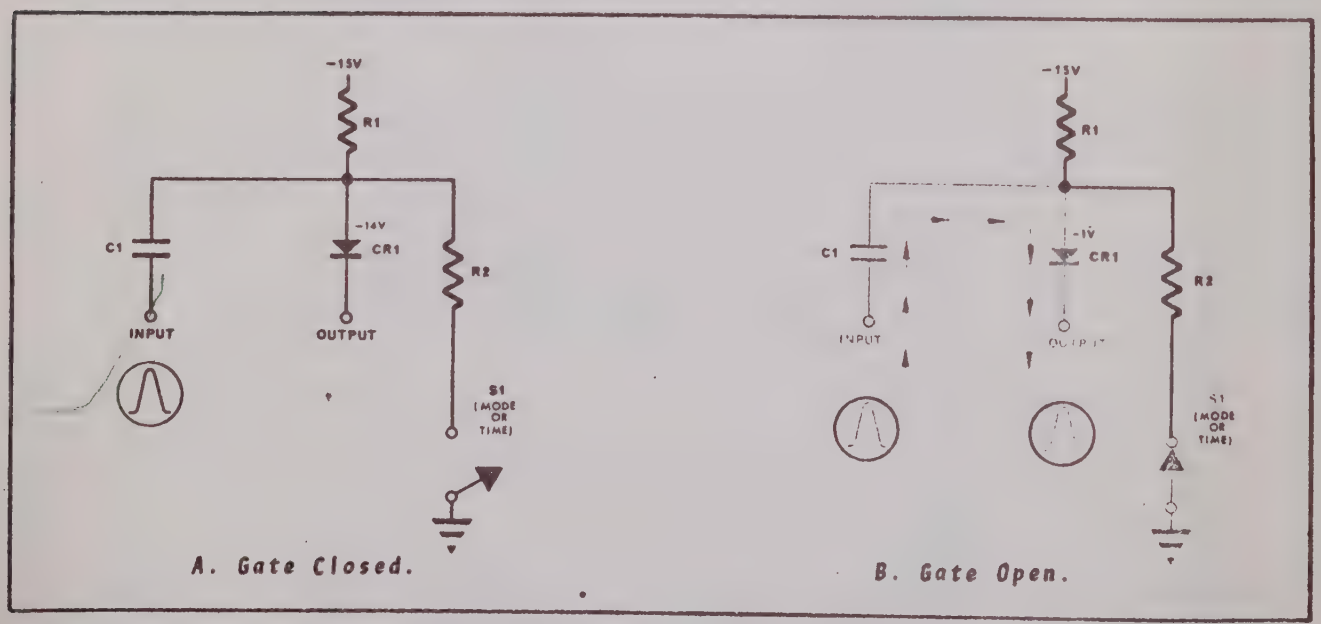


FIG. 3-2. Typical Logic Circuit.

3.2.1 "S" Logic

The "S" Logic circuit generates start and stop pulses to the control circuitry. The MODE selector controls the diode gates in the "S" Logic; main mode switching is accomplished in this circuit. Figure 3-4 shows "S" Logic for the TEST mode.

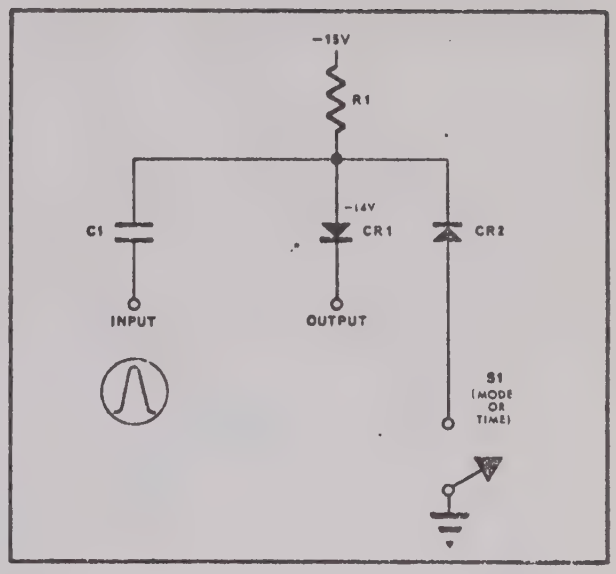


FIG. 3-3. Typical Logic -- Alternate Configuration.

3.2.2 "XY" Logic

The "XY" Diode Logic is controlled by the Slope switches and determines which slope (positive or negative) will start and stop the counting period. Figure 3-5 shows "XY" Logic for X inputs, + Start, and + Stop conditions.

3.2.3 Time Base Logic

Controlled by the TIME selector, the time base logic selects the desired time base output from the frequency dividers. The selected time base is fed through shaper stage Q1, Q2 for amplification and pulse shaping. The shaper is described in detail under "Basic Circuits", paragraph 3.9. Operation of the time base logic is discussed further in paragraph 3.4.

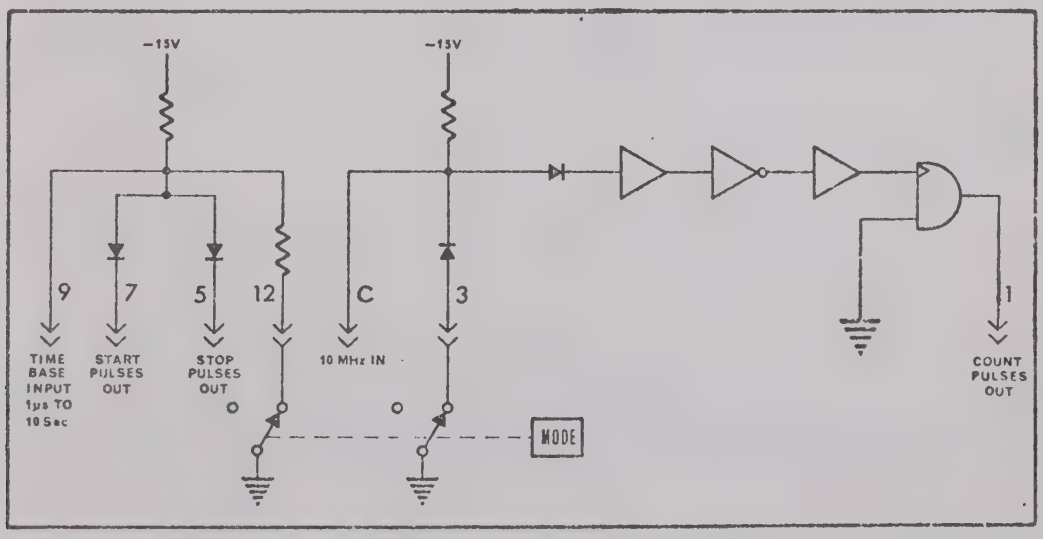


FIG. 3-4. S Logic -- TEST Mode.

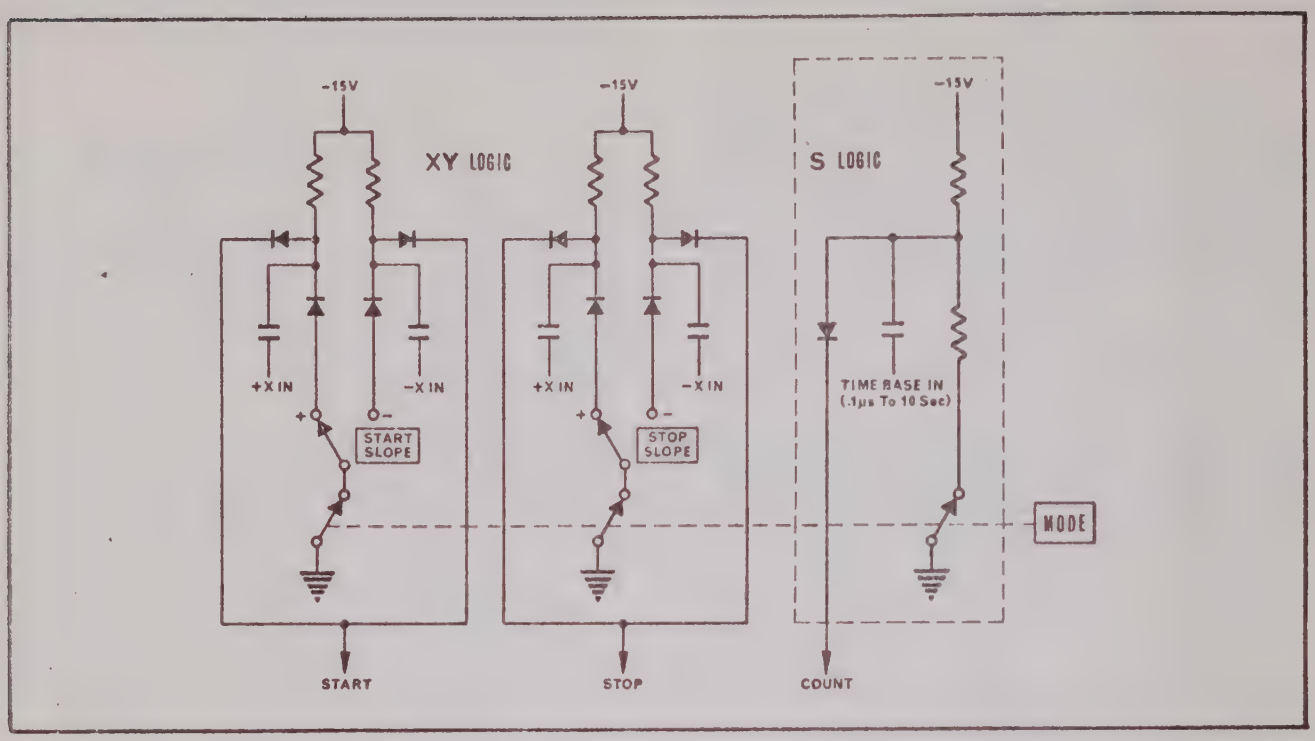


FIG. 3-5. XY and S Logic -- 1 PER X Mode.

3.2.4 "M" Logic

"M" Logic is used in multiple period positions of the MODE selector. As shown in Figure 3-6, there are two sets of AND gates in the "M" Logic. One set (CR7, CR12, CR17, CR22, CR27, and CR32), controlled by S1-E, applies the X input signal (via the M One-Shot) to a selected DCU in the frequency divider chain. The other set (CR8, CR13, CR18, CR23, CR28, and CR33), controlled by S1-E through inverters Q6 through Q11, breaks the divider chain at the output of the DCU preceding the selected multiple period DCU to prevent time base and input signals from becoming mixed.

For example, if the MODE selector is set to 10^4 MULTIPLE PERIOD X, input X signals pass through AND gate CR12 which has been enabled by S1-E in the 10^4 position. The output of inverter Q7 closes AND gate CR13, since the input to the inverter is grounded by S1-E. Therefore, the output of A23 no longer drives A22 through CR13, and the divider chain has been separated into two sections. Dividers A25, A24, and A23 can function as time base DCU's, while A22, A21, A20, and A19 are functioning as multiple period dividers. Simultaneous selection of an individual DCU for time base and multiple period use results in an incompatible position.

The multiple period output of the divider chain is fed through the M Shaper to the Control circuit (via S Logic) as start-stop pulses.

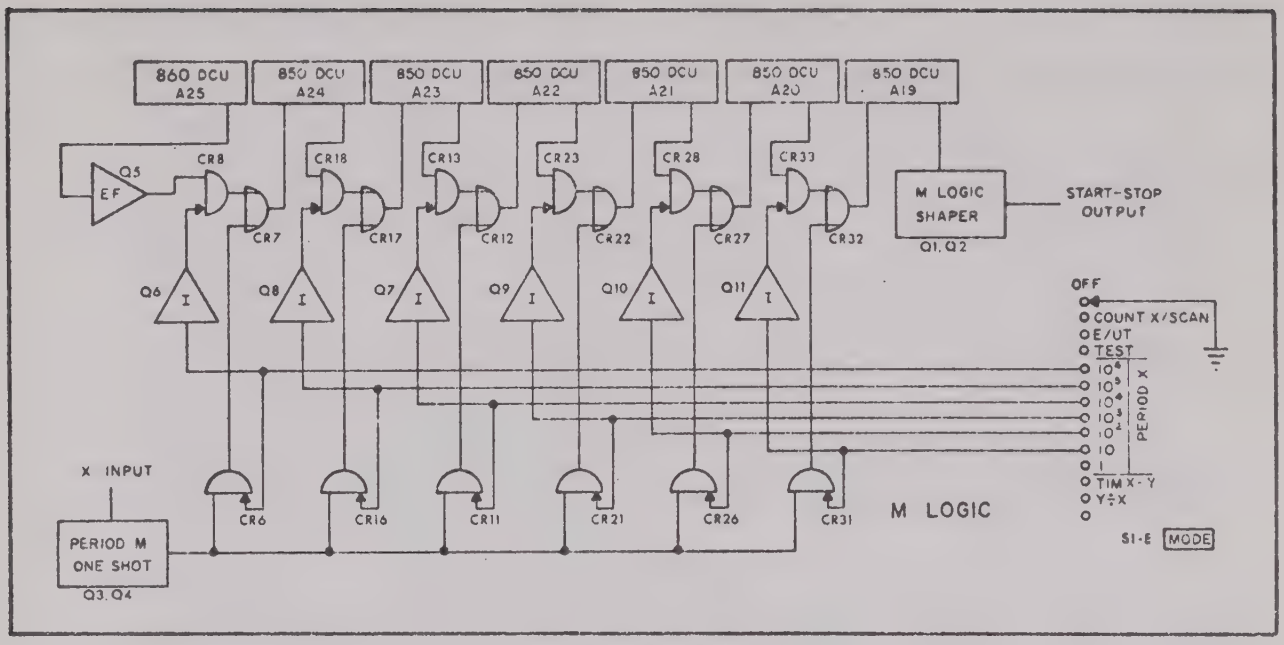


FIG. 3-6. M Logic.

3.3 INPUT CIRCUIT

As shown in Figure 3-7, the input circuit comprises five major sections: attenuator, amplifier, voltage discriminator (Schmitt trigger circuit), a pair of pulse amplifiers, and Count X and Multiple Period gates.

The function of the input circuit is to generate pulses of uniform size and shape which represent the input signal. Each time the attenuated input signal passes through a selected voltage level, the input circuit produces an output pulse which is independent of input waveform shape.

Output pulses are used for either of two purposes. For frequency measuring modes, the pulses are counted during a precise time base interval. For period or time interval measurements, the pulses are used as start-stop signals which open and close the signal gate.

3.3.1 Attenuator

The attenuator divides the input signal by a factor of 1, 10, or 100 as selected by the ATTEN control. Input resistance is 20K ohms for ATTEN 1, 200K ohms for ATTEN 10, and 2 megohms for ATTEN 100. All attenuator settings are shunted with approximately 40 pf.

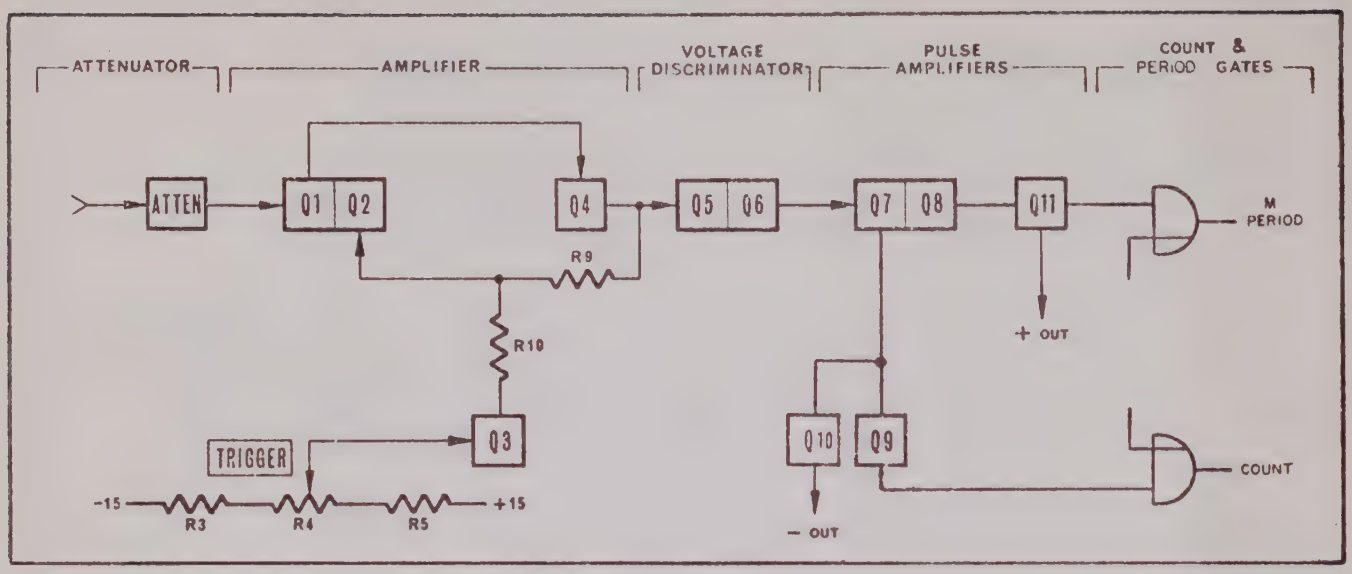


FIG. 3-7. Input Circuit Block Diagram.

When the ATTEN control is set to an AC position, 1.01 microfarads (C2 and C8) are inserted in series between the input connector and the attenuator. In DC, the entire input (ac signal and dc level) is coupled to the attenuator.

3.3.2 Amplifier

Amplification of the input signal occurs in transistor stages Q1, Q2, and Q4. Amplifier gain is determined primarily by the amount of feedback from transistor Q4 to Q2, and this level depends on the ratio of R9 to R10.

The dc level at the input of the voltage discriminator is determined by transistor Q3 which is controlled by the TRIGGER control (R4). This control is able to shift the ac signal at the base of transistor Q5 ±1 volt, thereby allowing a selected portion of the signal to pass through the hysteresis range of the voltage discriminator.

3.3.3 Voltage Discriminator

The voltage discriminator (Q5, Q6) produces a square-wave output which is independent of the input waveform shape. Triggering of the circuit occurs when the signal at the base of Q6 passes through the hysteresis range of the voltage discriminator. The circuit returns to its original state when the input signal passes back through the hysteresis range. The output square wave is fed to pulse amplifiers Q7 and Q8.

Detailed operating principles of the voltage discriminator appear in paragraph 3.9.

3.3.4 Pulse Amplifiers

In addition to amplifying and shaping the output of the voltage discriminator, the pulse amplifiers (Q7 and Q8) provide two sets of pulses which are 180 degrees out of phase with each other to effect polarity selection of the input waveform. As shown in Figure 3-8, when the discriminator output goes positive (corresponding to a minus to plus change at its input), Q7 produces a negative pulse and Q8 produces a positive pulse. Conversely, when the discriminator output goes negative (plus to minus change at its input), Q7 produces a positive pulse and Q8 produces a negative pulse. Since the logic circuits respond to positive pulses, only one of the pulse amplifier outputs is used for a given voltage change at the input of the discriminator.

With the SLOPE switch set to "-", the output of Q10 is used. With a "+" SLOPE setting, the output of Q11 is used. For all multiple periods only Q11 gated output is used.

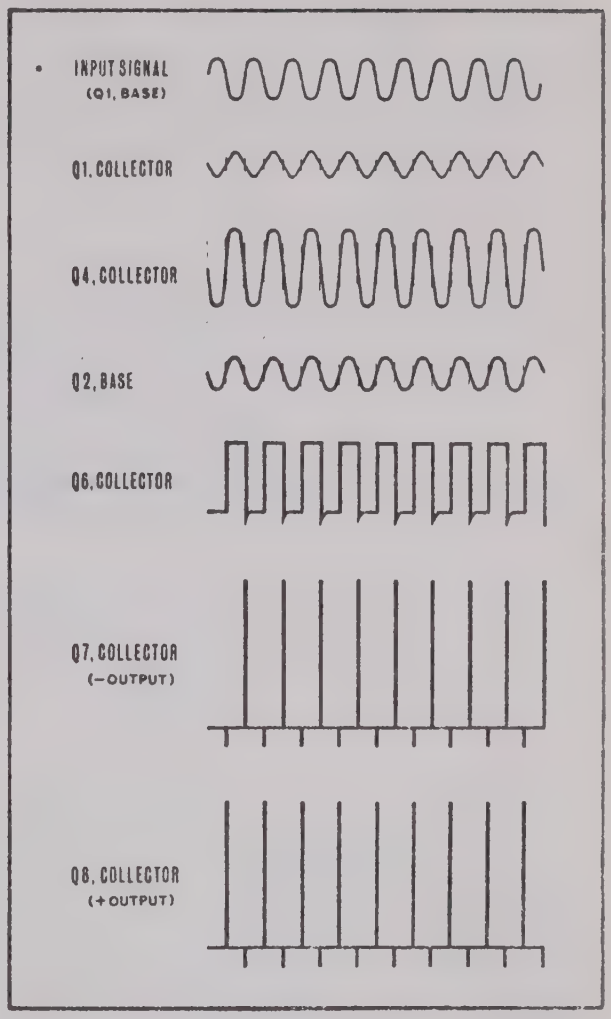


FIG. 3-8. Input Circuit -- Idealized Waveforms.

3.4 TIME BASE GENERATOR

The time base generator consists of the 1 MHz precision oscillator, 10 MHz multiplier, frequency divider chain, and time base logic. See Figure 3-9, Time Base Block Diagram.

Depending on the operating mode, the precise frequencies produced by the time base generator are used either as control (start-stop) or as count signals. The TIME selector setting determines which of the precise frequencies (0.1 microsecond to 10 seconds in decade steps) will be used.

3.4.1 Precision Oscillator and Oven Control

3.4.1.1 Oven Control

As shown in Figure 3-10, the 1 MHz crystal (Y1) is housed in a double oven. The outer oven, heated with a 117 volt ac element, is maintained at 70 degrees C ($\pm$0.5

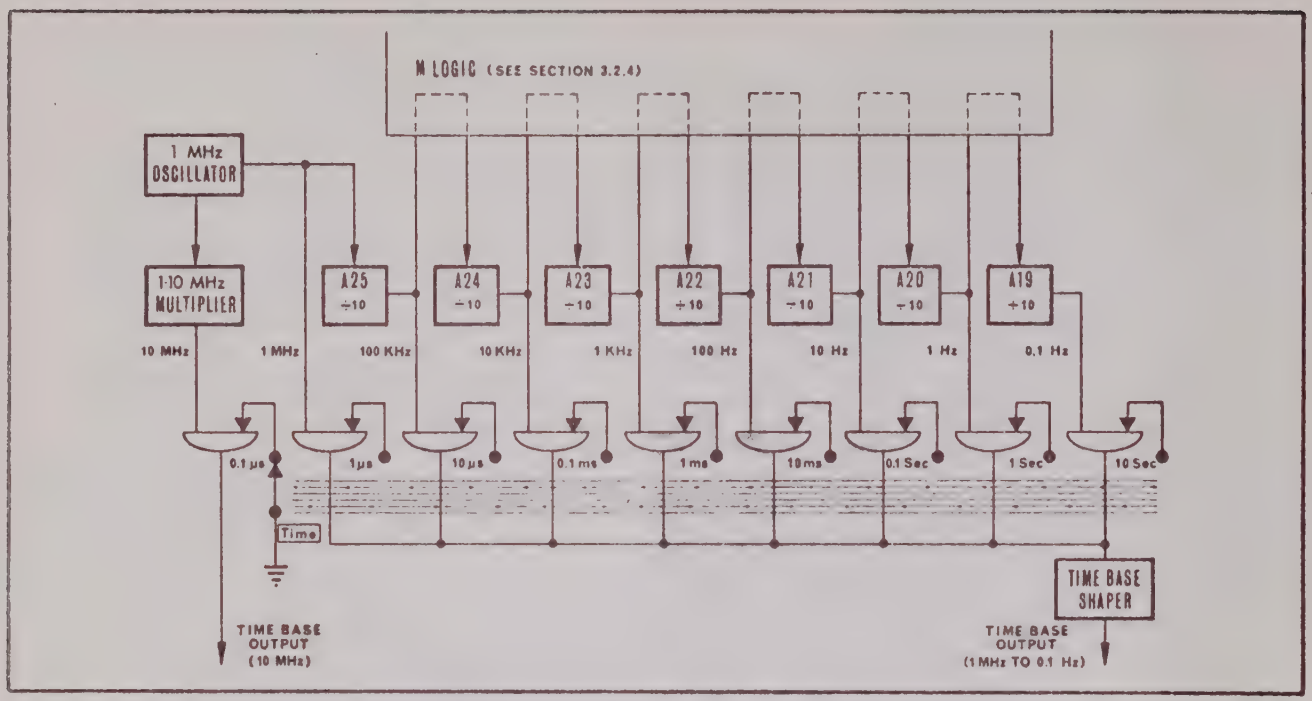


FIG. 3-9. Time Base Block Diagram.

degree) by thermostatic control. Thermistor RT51 senses the outside oven temperature and controls the bias on Q55, which drives Q56. Q56 controls the Silicon Controlled Rectifier SCR51 which then turns the SCR Control Heater on and off to maintain a constant temperature.

The inner oven, using proportional control, is kept at a nominal 75 degrees C (±0.005 degree). The heating element for the inner oven is a resistance bridge in which the opposite arms of the bridge are made of a material whose resistance changes in proportion to temperature. The bridge is energized by the output of an amplifier (Q51 through Q54). Amplifier and bridge form a closed-loop oscillatory circuit with an error signal from the unbalanced bridge providing the required feedback. The error signal is proportional to the difference

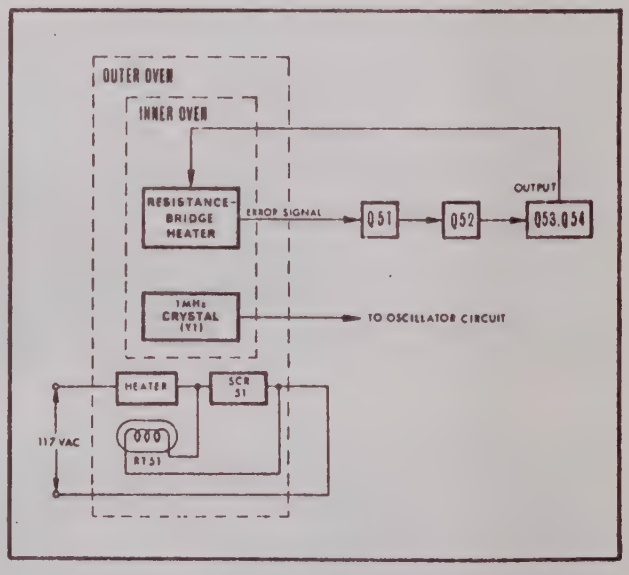


FIG. 3-10. Oven Control Block Diagram.

between actual and preset design temperature of the oven. If oven temperature begins to drop below design temperature, feedback is in phase and amplifier output increases. If oven temperature begins to exceed design temperature, feedback is out of phase, thus reducing the amplifier output. Since there is a continuous transfer of heat from the inner to the outer oven, temperature control of the inner oven is uninterrupted.

3.4.1.2 Oscillator

The oscillator comprises a 1 MHz crystal (Y1) and transistor Q1, both of which are contained within the inner oven. Oscillator frequency is adjusted with capacitor C1 (coarse adjustment) and R26 (fine adjustment). The 1 MHz output signal is coupled through C5 to buffer stage Q2.

The output of transistor Q2 is amplified by Q3 and Q4 and fed to shaper stage Q5, Q6. The shaper produces positive pulses which are routed to the frequency dividers and the 1-10 MHz multiplier.

An external signal can be substituted for the oscillator by switching S6 to EXT (external) and applying the external reference signal to connector J4.

3.4.2 1-10 MHz Multiplier

The 1 MHz signal from the oscillator circuit drives multiplier stage Q1. The collector circuit of Q1 is tuned to 10 MHz with inductor L1. The output is taken from the junction of C7 and C8, and drives the count gate circuit. Another output is available across L2 and is terminated at J7 for use with plug-in accessories.

3.4.3 Frequency Dividers

Cascaded decimal counting units (DCU's) comprise the frequency dividers. Each DCU produces one output pulse for every ten input pulses.

The first DCU (A25), driven by the 1 MHz oscillator, produces a 100 kHz output; the second DCU (A24) produces a 10 kHz output; and the third DCU (A23) produces a 1 KHz output. This dividing process continues down the chain until the 1 Mhz signal has been divided down to 0.1 Hz. The desired time base frequency is selected with the TIME selector on the front panel.

The frequency dividers have a dual function. They may be used to divide the 1 MHz oscillator frequency to provide time bases of 10 microseconds to 10 seconds; or they may be used to divide the X input signal for multiple period operation. Logic gates in the time base logic and "M" logic circuits control inputs and outputs to the frequency dividers.

If a DCU is selected for both time base and multiple period operation, a signal is fed to the data storage units which produce the digit "8" on the EL panel,

denoting an incompatible selector setting. Refer to the appended manuals for further information on DCU operation.

3.5 CONTROL

The control section regulates the flow of pulses from other major sections (inputs X and Y, time base, etc.) to the count DCU's. This section consists of the start and control binaries and the signal gate (gate control).

Briefly, the control section functions as follows (see Figure 3-11): upon application of a "start" pulse, the start and control binaries "flip", allowing the signal gate to open in the first counting DCU. While the signal gate is open, "count" pulses pass through the gate to be totaled by the count DCU's. The DCU's continue to register counts until a stop pulse is applied to the control binary which flips, closing the signal gate. The accumulated count in the DCU's transfers to data storage (DSU's), and is displayed on the EL panel. The method used to transfer information from the DCU's to the DSU's is described in paragraph 3.6 (Recycle). Figure 3-12 shows the timing of the control section.

Upon completion of the count period, a control signal is initiated at the Reset Control circuit and fed to the Recycle circuitry. The duration of the Control signal is determined by the Reset pulse, and it terminates when a Reset pulse is applied to the tunnel diode binary.

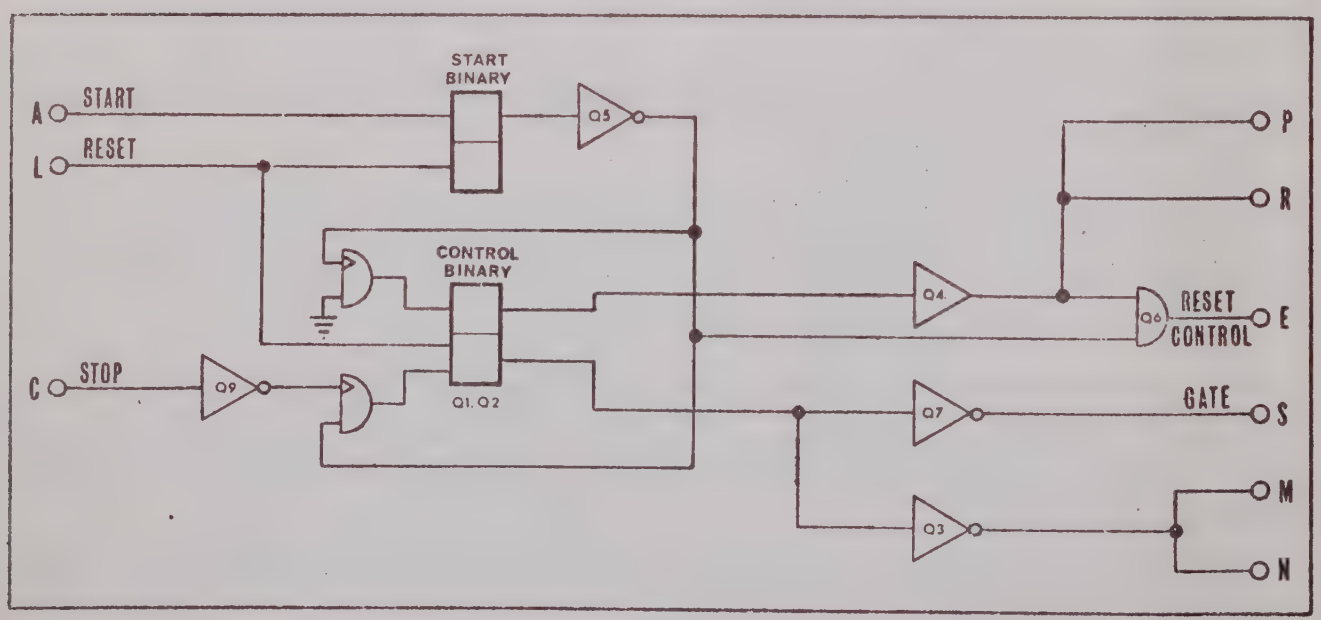


FIG. 3-11. Control Circuit Block Diagram.

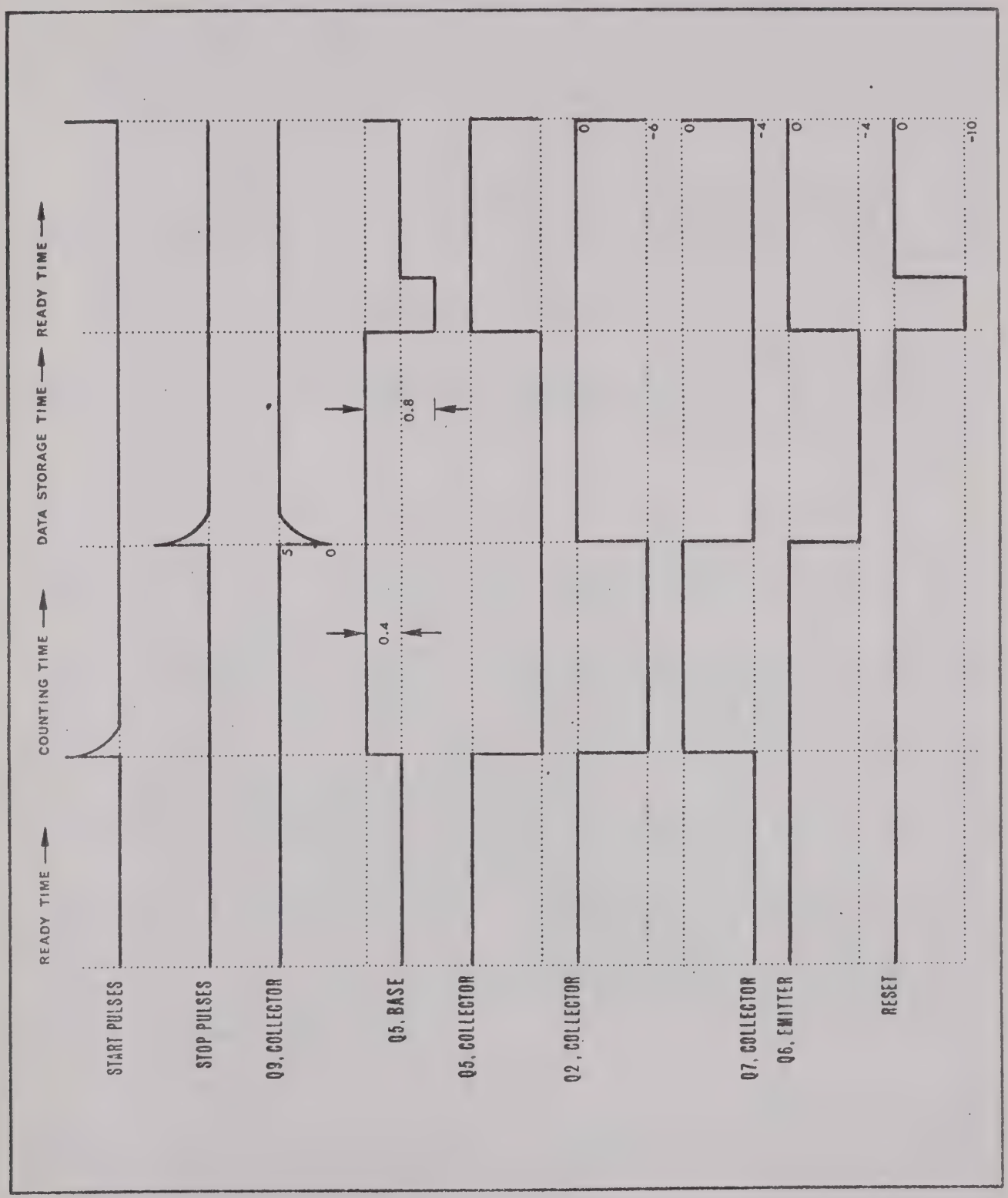


FIG 3-12. Control Circuit Timing.

3.5.1 Ready Time

Ready time is defined as the time when the control section is prepared to accept a start pulse to begin a timing period. Start and control binaries are reset and the signal gate is closed.

3.5.2 Count Time

Counting time is defined as the interval between a start pulse and a stop pulse, during which time the signal gate is open.

3.5.3 Data Storage Time

Data storage time is defined as the interval between a stop pulse, plus 10 microseconds clear and set time, to the next stop pulse.

3.6 RECYCLE

As shown in Figure 3-13, the recycle circuit is a major timing link between control and storage, and between storage and accessory equipment.

Recycle rate is controlled by three factors: 1) length of counting time, 2) speed of accessory equipment, and 3) setting of the RECYCLE RATE control. As shown in the Timing Diagram (Figure 3-14), counting time is variable between 1 microsecond and 10 seconds and recycle time variable between 150 milliseconds and 10 seconds. Before reset can be initiated to ready control circuits for another timing interval, the previous count and recycle intervals must be completed. Also, accessory equipment must be finished in its accumulation of data from the previous cycle. If the count interval is longer than the preset recycle rate, it takes precedent in determining recycle time of the instrument.

The recycle circuits have two distinct operating "modes". In LATCH mode, the EL display changes only when the total count changes. In FOLLOW mode, the display "follows" the counting progression of the DCU's.

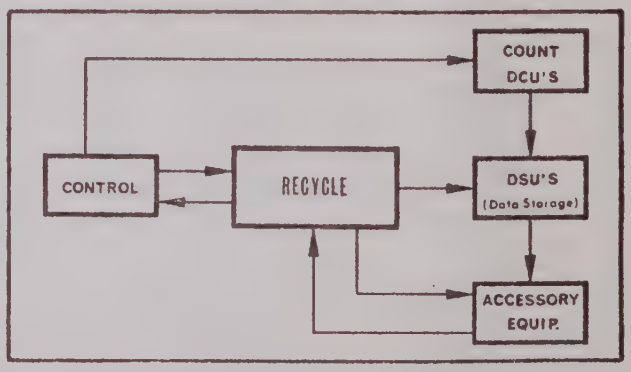


FIG. 3-13. Recycle Sub-System.

3.6.1 LATCH Mode

Circuit logic for the LATCH mode is shown in Figure 3-15.

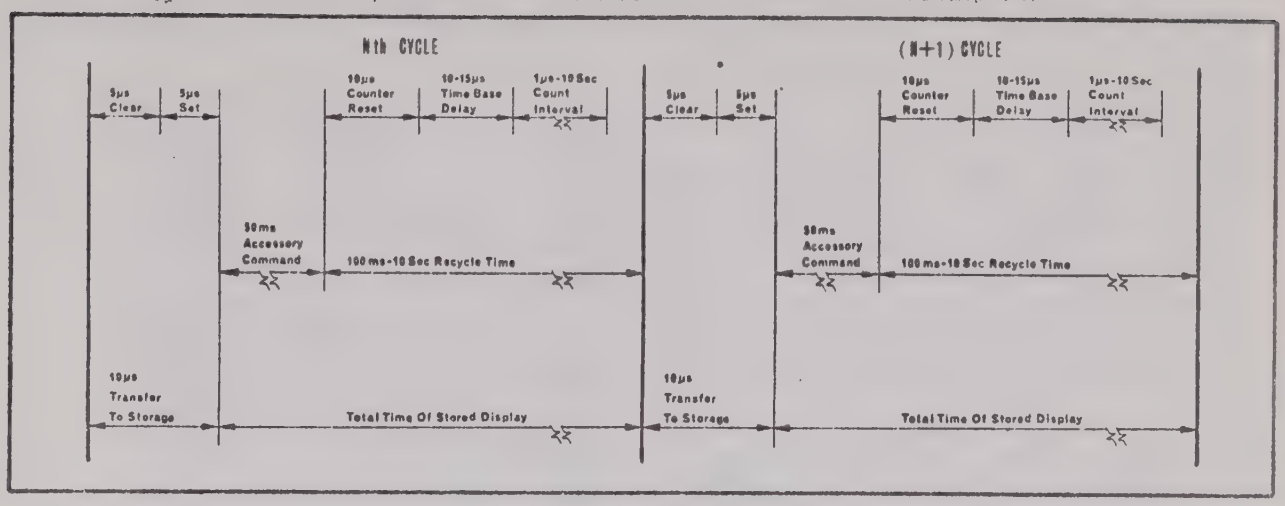


FIG 3-14. Recycle Timing.

3.6.2 FOLLOW Mode

Circuit logic for the FOLLOW mode is shown in Figure 3-16. Operation is identical to LATCH during Data Storage Time (interval between end of one counting time to the start of a new counting time). The two modes differ in operation during counting time.

During counting time (in FOLLOW), information being totaled in the count DCU's is being sampled at a 500 Hz rate. This is done by driving the Clear and Set One-shots with a 500 Hz signal derived from the Display Power Supply.

3.6.3 Recycle Rate Generator and Control

As stated previously, the three factors that determine recycle rate are counting time (determined by TIME selector setting) speed of accessory equipment, and recycle rate (as set by the RECYCLE RATE control). If recycle rate is longer than count or accessory time, then the Recycle Rate Generator is the determining timing circuit of the instrument.

Figures 3-17 and 3-18 show the operation of the Recycle Rate Generator and Control. Figure 3-17 shows the circuit with the generator off; Figure 3-18 shows the generator on.

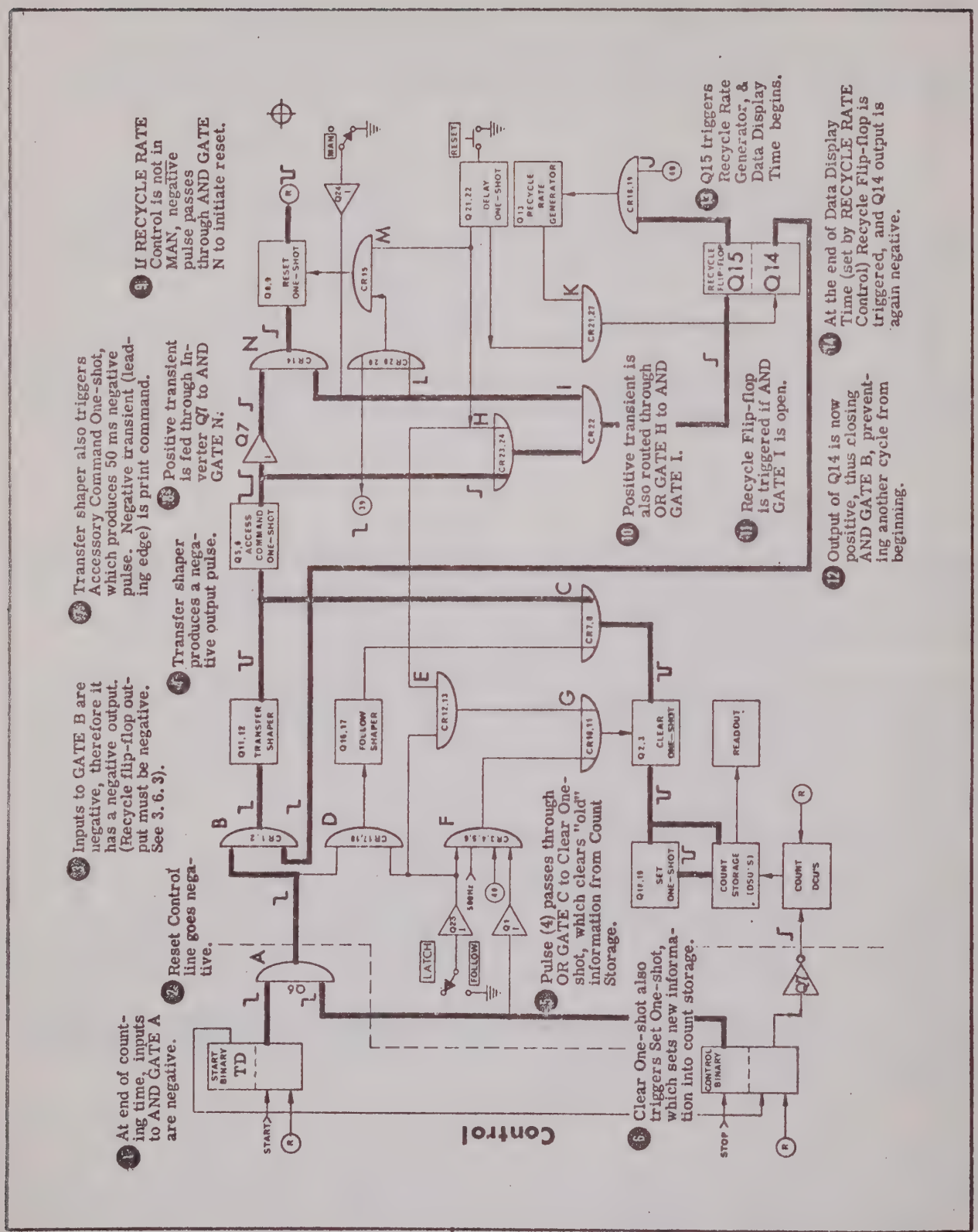

1 At end of counting time, inputs to AND GATE A are negative.
2 Reset Control line goes negative.
3 Inputs to GATE B are negative, therefore it has a negative output. (Recycle flip-flop output must be negative. See 3.6.3).
4 Transfer shaper produces a negative output pulse.
5 Transfer shaper also triggers Accessory Command One-shot, which produces 50 ms negative pulse. Negative transient (leading edge) is print command.
6 Clear One-shot also triggers Set One-shot, which sets new information into count storage.
7 Pulse (4) passes through OR GATE C to Clear One-shot, which clears "old" information from Count Storage.
8 If RECYCLE RATE Control is not in MAN, negative pulse passes through AND GATE N to initiate reset.
9 Positive transient is fed through Inverter Q7 to AND GATE N.
10 Positive transient is also routed through OR GATE H to AND GATE I.
11 Recycle Flip-flop is triggered if AND GATE I is open.
12 Output of Q14 is now positive, thus closing AND GATE B, preventing another cycle from beginning.
13 Q15 triggers Recycle Rate Generator, & Data Display Time begins.
14 At the end of Data Display Time (set by RECYCLE RATE Control) Recycle Flip-flop is triggered, and Q14 output is again negative.
Control
START
STOP
START BINARY TD
CONTROL BINARY
LATCH
FOLLOW
Q23
Q1
50KHz
Q11,12 TRANSFER SHAPER
Q16,17 FOLLOW SHAPER
Q3,4 ACCESS COMMAND ONE-SHOT
Q8,9 RESET ONE-SHOT
Q18,19 SET ONE-SHOT
Q2,3 CLEAR ONE-SHOT
COUNT STORAGE (DSU'S)
READOUT
COUNT DCU'S
Q7
Q24
MAN
RESET
Q21,22 DELAY ONE-SHOT
Q13 RECYCLE RATE GENERATOR
RECYCLE FLIP-FLOP
Q15
Q14
CR1,2
CR3,4,5,6
CR7,8
CR12,13
CR14,15
CR17,18
CR20,28
CR21,27
CR22
CR23,24
CR18,11
A
B
C
D
E
F
G
H
I
K
L
M
N

FIG. 3-15. Recycle Functional Block Diagram -- LATCH

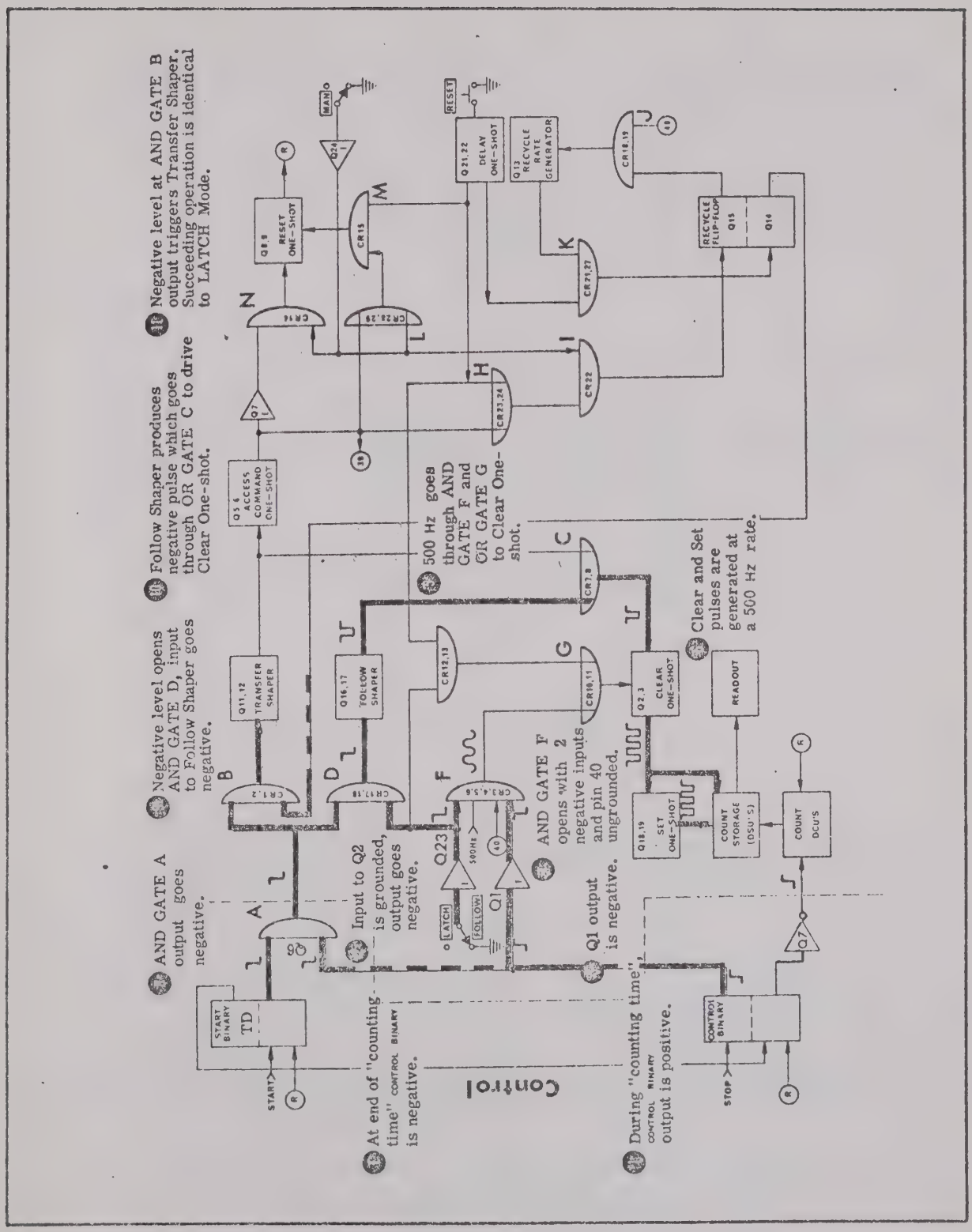
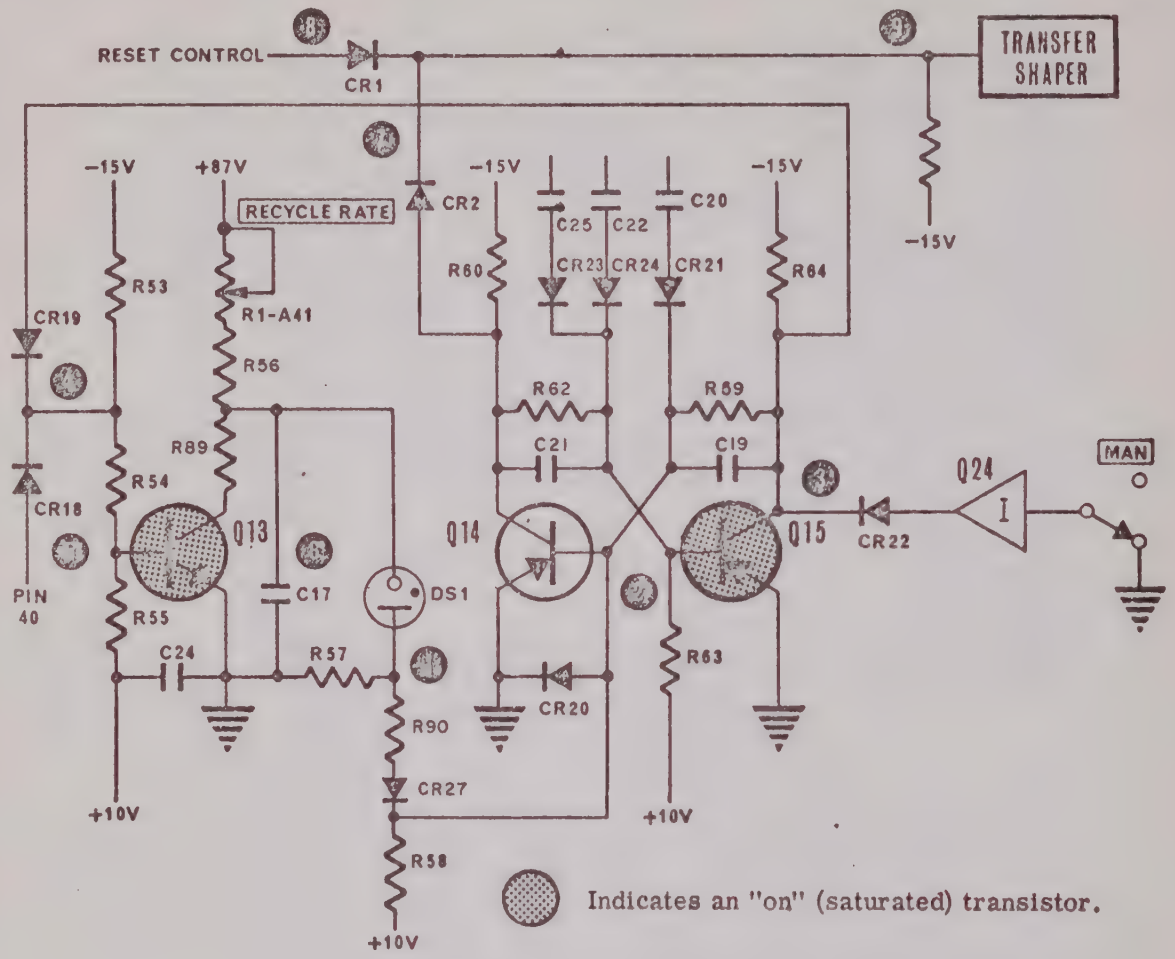
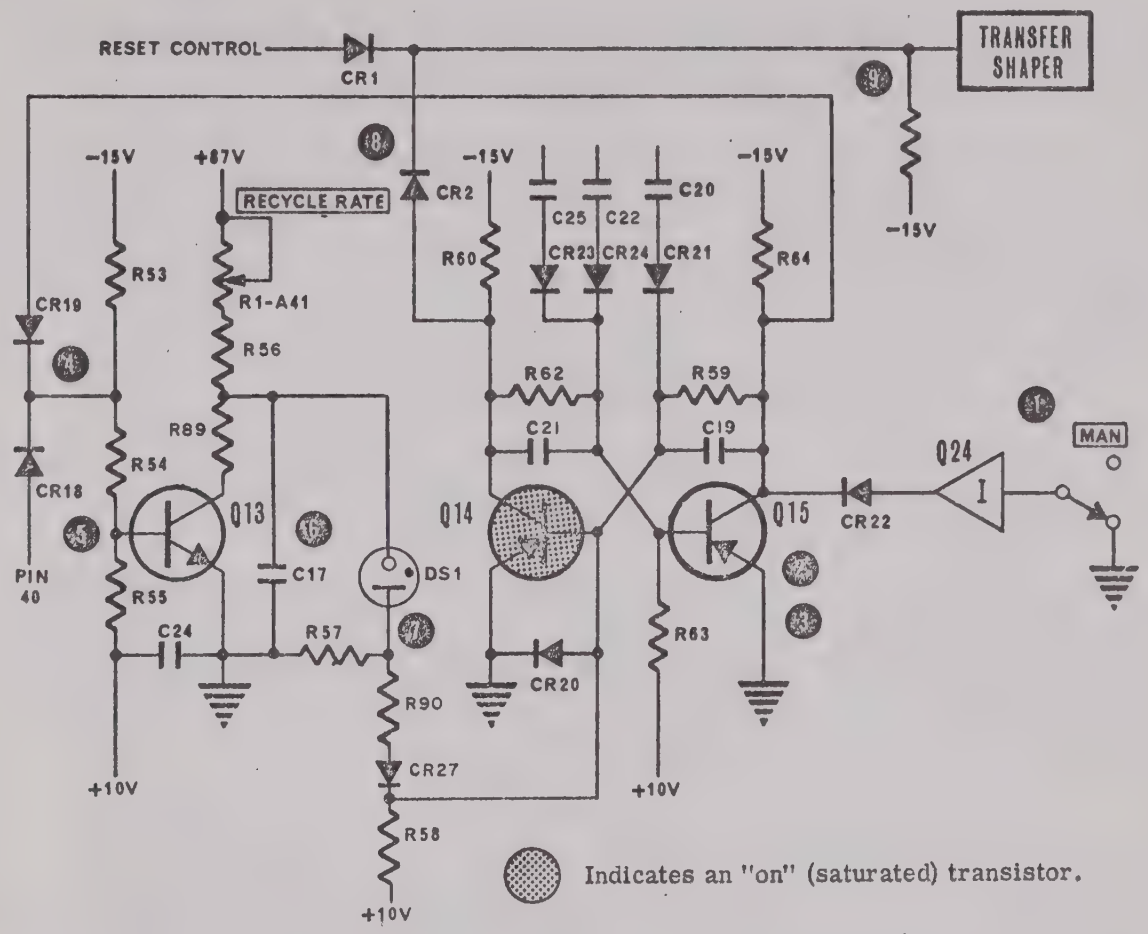


FIG. 3-16. Recycle Functional Block Diagram -- FOLLOW.



1. At end of selected recycle time, DS1 fires, producing positive pulse.
2. Positive pulse turns Q14 off, Q15 on.
3. Q15 collector goes positive (from -15 volts to near ground potential).
4. CR19 conducts, clamping bottom of R53 to ground, which electrically removes R53 from divider network R53, 54, 55.
5. Q13 base becomes positive, Q13 turns on and discharges C17.
6. C17 cannot charge since available charging current is bypassed through Q13.
7. Q14 collector is negative; therefore, CR2 turns off.
8. CR2 turns off. CR1 may or may not be of, depending upon selected time base interval vs. recycle time.
9. When both diodes of ⑧ are off, transfer shaper produces negative pulse to begin new cycle, beginning with the accessory command signal.

FIG. 3-17. Recycle Rate Generator - 'Off'.



1. With RECYCLE RATE control at MAN, automatic recycle is disabled by holding Q15 collector near ground potential.
2. With Q15 unclamped (switch not in MAN), it can be triggered by a positive pulse from Delay One-Shot (through CR23) or Accessory Command One-Shot (through CR24).
3. Positive pulse turns Q15 off, Q14 on. Q15 collector goes negative.
4. CR19 turns off, unclamping R53.
5. Q13 base goes negative, Q13 turns off.
6. C17 begins to charge through R56 and R1-A41. Charge time is determined by RECYCLE RATE setting.
7. C17 charges until firing potential of DS1 is reached.
8. Q14 collector is near ground during C17 charge time; therefore, CR2 is conducting.
9. Conduction of CR2 keeps Transfer Shaper input near ground, and it cannot be triggered.

FIG. 3-18. Recycle Rate Generator - 'On'.

3.6.4 Delay One-Shot

Consisting of transistors Q21 and Q22, the Delay One-Shot produces a 15 millisecond pulse when triggered by the RESET button. Detailed operating theory of the one-shot is included in paragraph 3.9; therefore, only the function of the Delay One-Shot with other circuits will be described here.

The base of Q22 goes positive when the RESET button is pressed, thus triggering the one-shot. The positive transient at the collector of Q22 turns Q14 off and Q15 on, thereby turning Q13 on and discharging C17. Approximately 15 milliseconds later the positive transient at the collector of Q22 turns Q15 off, Q14 on, and Q13 off allowing C17 to charge to the potential set by the RECYCLE RATE control.

The positive transient at the collector of Q22 also triggers the Reset One-Shot which resets count DCU's and gate-control circuits.

3.6.5 Reset One-Shot

The Reset One-Shot is preceded by a buffer amplifier (Q7) and followed by an emitter follower (Q10). Reset is triggered by a positive transient from the Accessory Command One-Shot or by a positive transient from the Delay One-Shot. The reset circuit produces a 10 microsecond negative pulse which resets count DCU's and binaries in the gate-control circuit. See paragraph 3.9 for further information on the operation of the typical one-shot.

3.6.6 Accessory Command One-Shot

Triggered by the Transfer Shaper, the Accessory Command One-Shot produces a 50-millisecond negative pulse. The leading edge (negative transient) of this pulse is the print command, which is routed via pin 39 of J9 to the accessory equipment. Fifty milliseconds after the print command has been issued, the trailing edge (positive transient) triggers the Reset One-Shot and the Recycle control.

3.6.7 Clear and Set One-Shots

Respectively, the Clear and Set One-Shots clear "old" information from the Data Storage Units and set in "new" information.

The Transfer Shaper triggers the Clear One-Shot which resets the binaries of the Data Storage Units. The Clear One-Shot also triggers the Set One-Shot which allows transfer of data from DCU's to DSU's. This process of clearing and setting is described in more detail in the appended DSU manual.

3.7 LEGEND

The legend printed circuit board comprises two separate sections. The front section contains the decoding matrix which controls the unit of measurement nomenclature on the EL panel. The rear section contains the circuits which drive the GATE OPEN light.

3.7.1 Decoding Matrix

The legend decoding matrix is similar to the matrix used in the Data Storage Unit. (See the appended DSU manual.) However, in the legend circuit, switch contacts (rather than transistors) are used to control the on/off voltages to the EL segments.

Figure 3-19 shows the basic decoding circuit, which uses a photoconductor as the variable arm of a voltage divider. When the photoconductor is in total darkness, resistance is high. When illuminated by the control lamp, the resistance is low. Thus, an EL segment connected across the photoconductor can be switched on and off by the lamp.

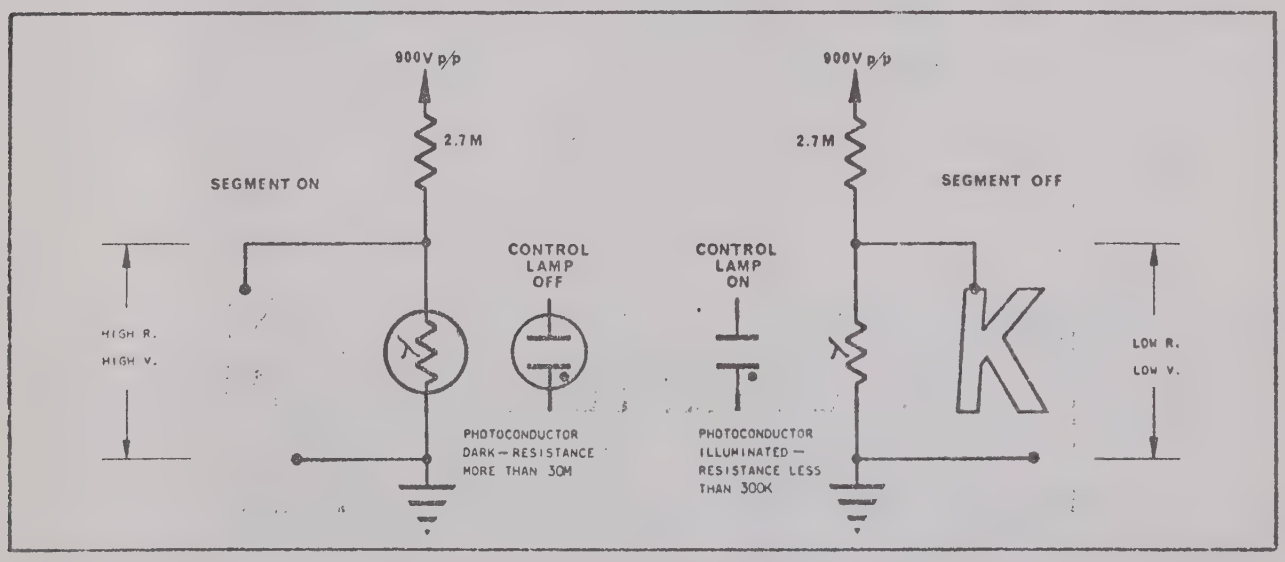


FIG. 3-19. Photoconductor Switching Circuit -- Simplified.

Figure 3-20 is a simplified block diagram of the legend decoding matrix.

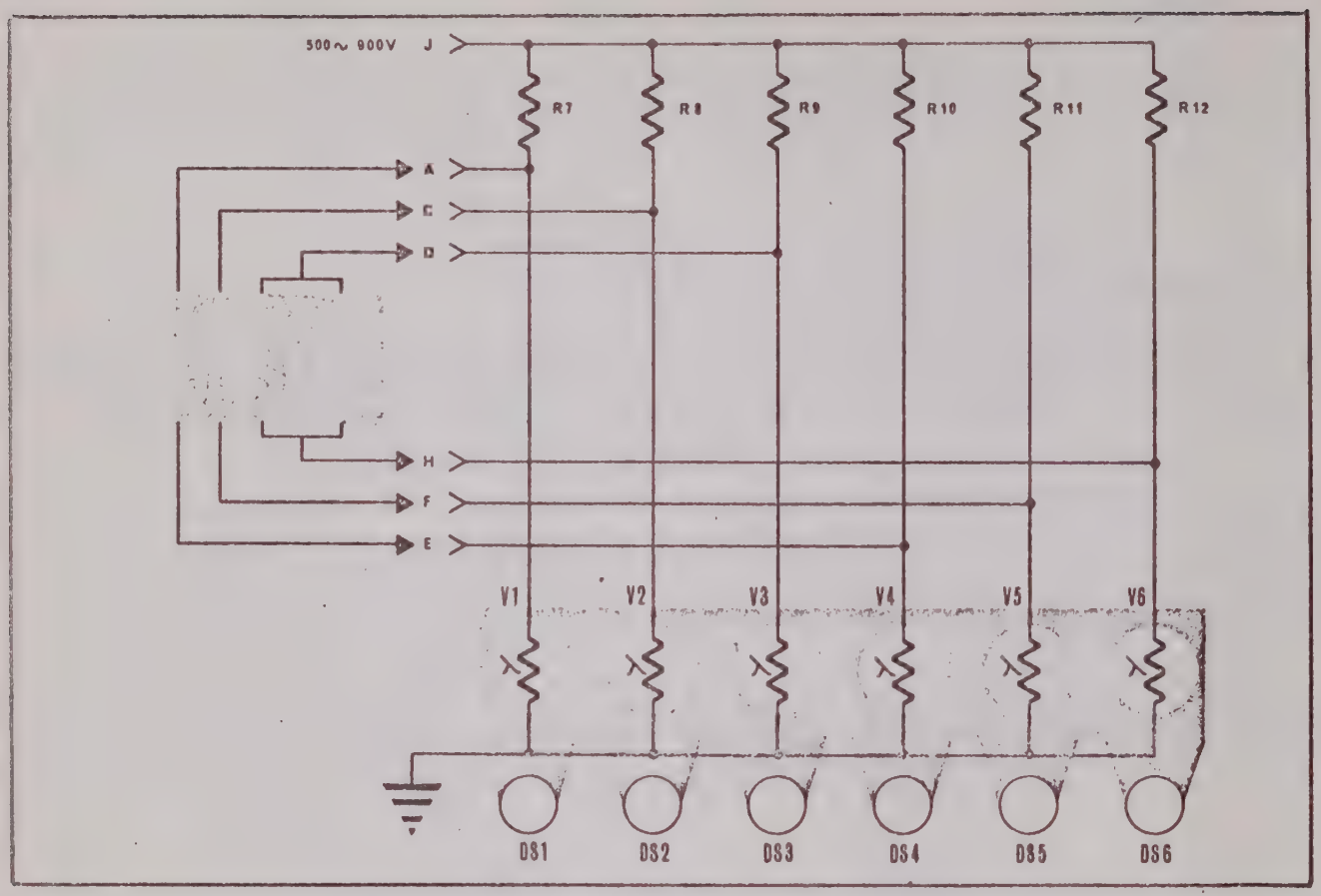


FIG. 3-20. Legend Circuit -- Simplified.

3.7.2 GATE OPEN Light

The GATE OPEN light is on during the interval that the signal gate remains open (counting time). Therefore, the light is turned on when the positive output of the start binary drives Q4 on the legend board. Transistor Q4 triggers the one-shot (Q1, Q2), which produces a negative pulse turning Q3 off. With Q3 off, +90 volts is developed across GATE OPEN light DS1. DS1 turns off when the control binary output drives Q3 base positive.

3.8 POWER SUPPLY

3.8.1 Primary Power

AC power is applied through line filter Z1 to the primary winding of power transformer T1. With power applied, 117 volts ac is provided for the oscillator oven control circuit and connector J7.

Relay K1 is energized when POWER switch S5-A is at OFF. With K1 energized, 1) +15 volts is provided for the oscillator circuits, 2) +90 volt supply is disabled, 3) -15 volt output is not available, and 4) fan motor has no power applied. K1 de-energizes when POWER switch is set to LATCH or FOLLOW.

3.8.2 Regulated -15 Volt and +15 Volt Supplies

The -15 volt supply consists of full-wave rectifier CR1; series regulator Q1; and reference amplifier A34Q1, A34Q2, and A34Q3. The +15 volt supply consists of full-wave rectifier CR2; series regulator Q2; and reference amplifier A34Q4, A34Q5, and A34Q6. Except for their difference in polarity, the -15 volt and +15 volt supplies are identical. Therefore, only the operation of the -15 volt supply will be described.

A portion of the -15 volts is fed back through divider network R3, R8, and R9 to the base of A34Q3. The output of A34Q3 controls the bias on A34Q2, thereby controlling current flow through A34Q2 to the base of Q1. Transistor A34Q1 acts as a constant current source for A34Q2.

If the -15 volt output begins to go more negative (toward -16 volts), A34Q3 base goes negative, conduction increases, and its collector potential goes positive. The base of A34Q2 goes positive, and current flow (through A34Q2) in the base circuit of Q1 decreases. With less base current, conduction through Q1 decreases, and output voltage decreases (back to -15 volts). The output voltage is maintained at a value set by potentiometer R8.

3.8.3 Regulated +10 Volt Supply

Derived from regulated +15 volts, the +10 volt supply consists of series regulator Q3 and reference amplifier A35Q3 and A35Q4. Changes in load voltage vary the bias on A35Q3, thereby varying the base current supplied to Q3. Transistor A35Q4 maintains emitter current of A35Q3 at a constant value. Potentiometer R4 sets the output voltage level.

3.8.4 Regulated +90 Volt Supply

The regulated +90 volt supply consists of full-wave rectifier CR3, reference amplifier A34Q7, and series regulator Q4. Operation of this supply is similar to that of the other regulated supplies. Changes in load voltage are reflected through A34Q7 which controls current through Q4. The emitter of A34Q7 is referenced to the +15 volt supply.

3.8.5 EL Supply (500 Hz, 900 Volts Peak-to-Peak)

The EL supply comprises a push-pull oscillator (A35Q1, A35Q2) utilizing transformer feedback. See Figure 3-21, simplified schematic of the EL supply.

Oscillation is maintained by inverting and feeding back part of the collector signal of each stage to its respective base. Transformer T2 (windings 4-5 and 1-3) provides the required 180 degree phase shift for regenerative feedback. The push-pull output signal is developed across transformer winding 5-7 and is stepped up to 900 volts peak-to-peak in winding 8-9. Frequency of oscillation is essentially determined by transformer winding and R1.

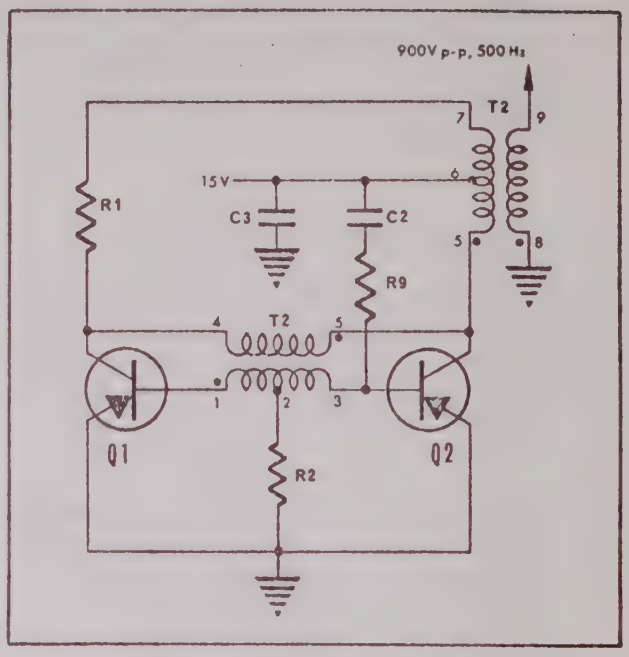


FIG. 3-21. EL Supply -- Simplified.

3.9 BASIC CIRCUITS

This section describes some of the basic circuits and circuit fundamentals which apply to the Model 6147. Information is intended to give the operator or technician a general understanding of the basic circuits, and no attempt has been made to describe how diodes or transistors function internally.

3.9.1 AND and OR Gate Circuits

The AND circuit is a multiple input circuit which requires all input signals in order to produce an output. Figure 3-22 shows two configurations of the AND circuit.

The OR circuit is a multiple input circuit which requires the presence of only one input signal in order to produce an output. Figure 3-22 shows an OR gate configuration.

3.9.2 Inverters and Emitter Followers

Logic inverting circuits provide a method of converting a logic 0 to a logic 1 or vice versa. Figure 3-23 shows the inversion operation and a typical inverting circuit.

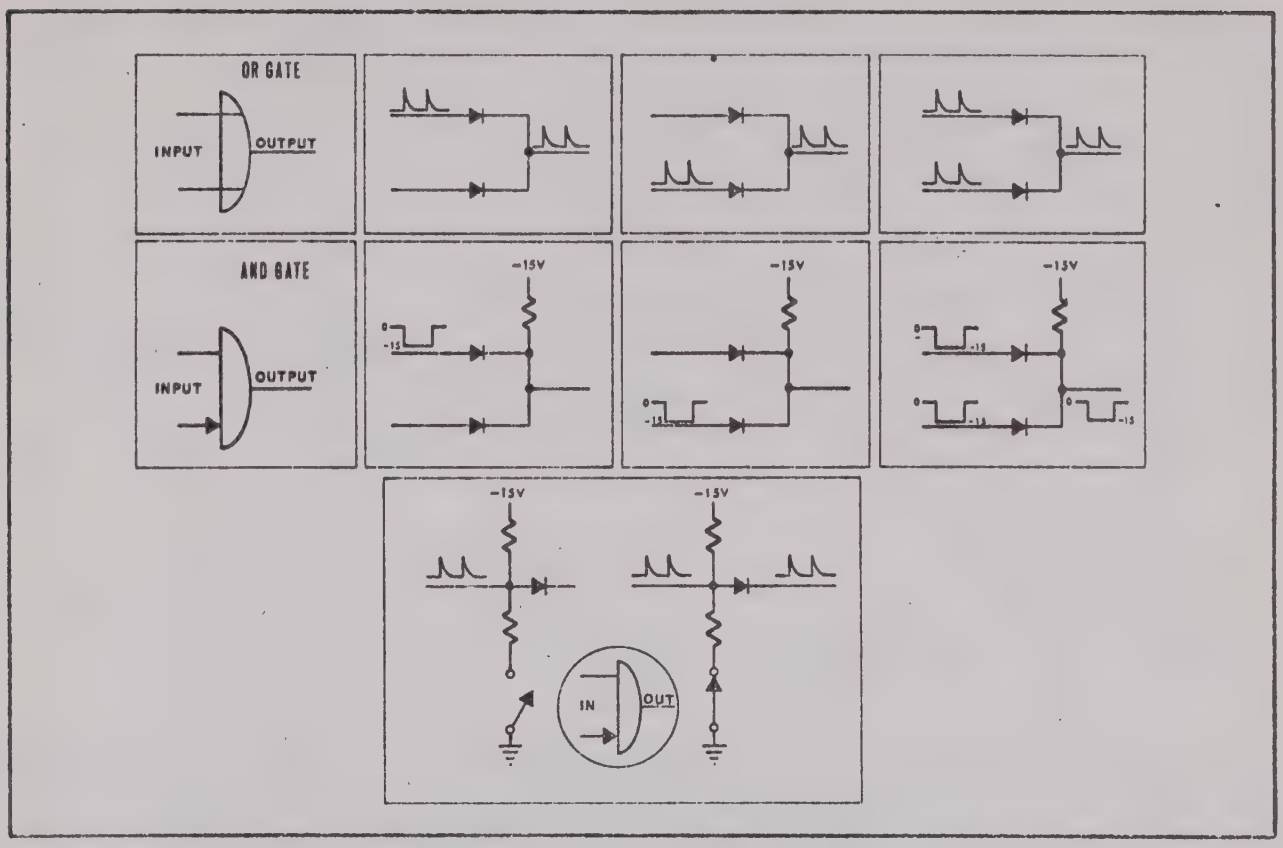


FIG. 3-22. Gate Circuits -- Typical.

An emitter-follower circuit is represented by the ▷ symbol (see Figure 23). The circuit is so named because the output at the emitter follows the input in phase. This circuit may be used as a current amplifier or as a coupling or impedance matching element.

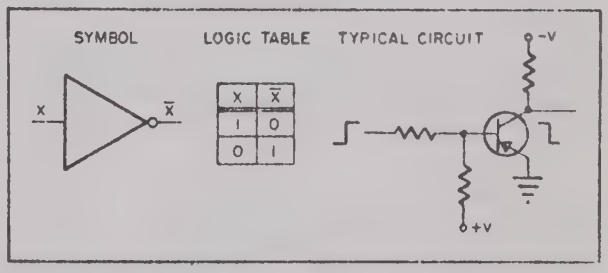


FIG. 3-23A. Typical Inverter.

3.9.3 Typical Binary

Shown in Figure 24 is a typical binary, or "flip-flop", using PNP transistors and positive-pulse steering. The circuit can exist in either of two stable states: Q1 on, Q2 off; or Q1 off, Q2 on. Positive input pulses trigger the binary from one stable state to the other through one of the pulse-steering diodes (CR1 or CR2).

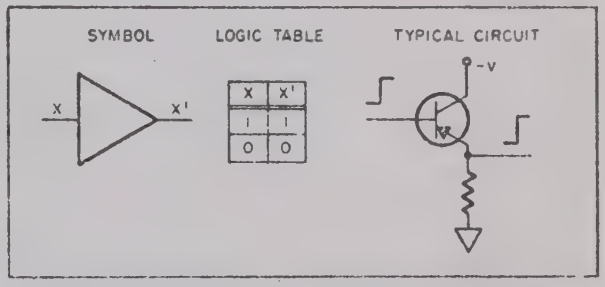


FIG. 3-23B. Typical Emitter Follower.

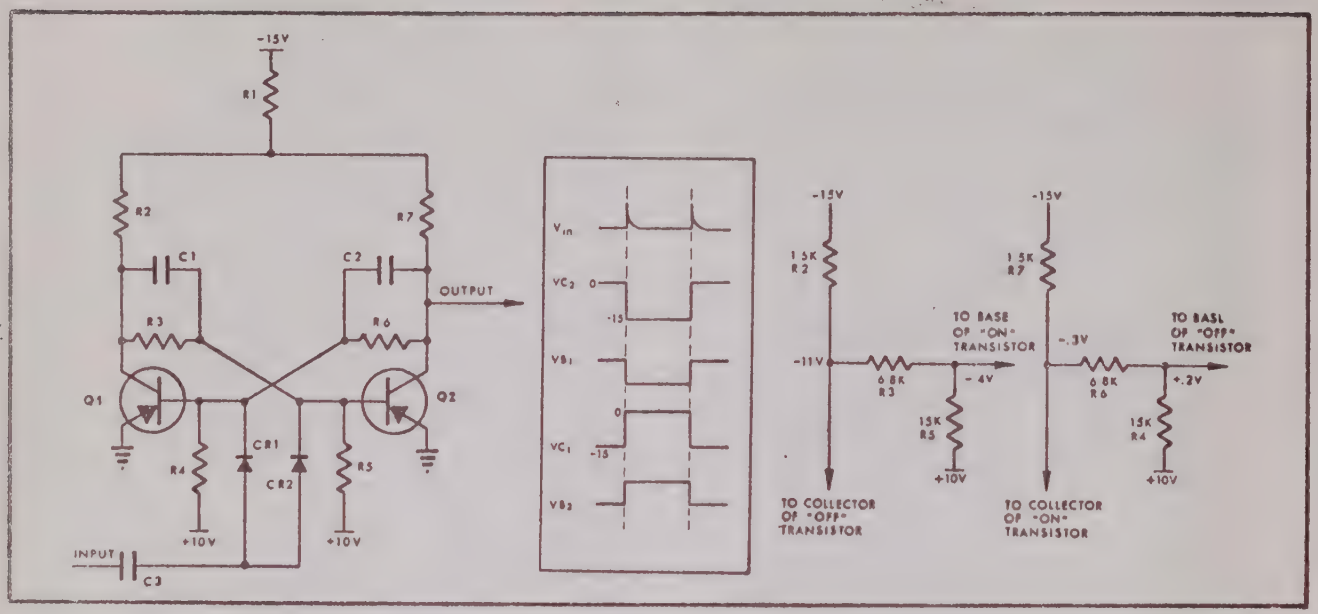


FIG. 3-24. Typical Binary.

Assume that transistor Q1 is conducting and transistor Q2 is cut off. A positive input pulse passes through CR1 to the base of Q1, turning Q1 off. As Q1 turns off, load current decreases and the collector potential approaches -15 volts. This negative transient is coupled through capacitor C1 to the base of Q2, turning Q2 on. Current through Q2 increases and its collector potential rises toward ground. Under these conditions, divider network R6-R4 maintains a positive potential at the base of Q1 to keep it cut off. (See Figure 3-24.)

The binary remains in this stable state (Q1 off, Q2 on) until the next positive input pulse arrives. At that time, Q2 cuts off, Q1 conducts, and the binary resumes its original state.

3.9.4 Typical One-Shot

A typical "one-shot" or monostable multivibrator, is shown in Figure 3-25. Transistor Q1 is held at cutoff and transistor Q2 at saturation by bias arrangement and transistor regeneration. A negative pulse is applied and the circuit functions until a full cycle is completed. Circuit timing is determined by the values of capacitor C1 and resistor R2.

A negative pulse is applied through coupling capacitor C2 to the base of transistor Q1, and it begins to conduct.

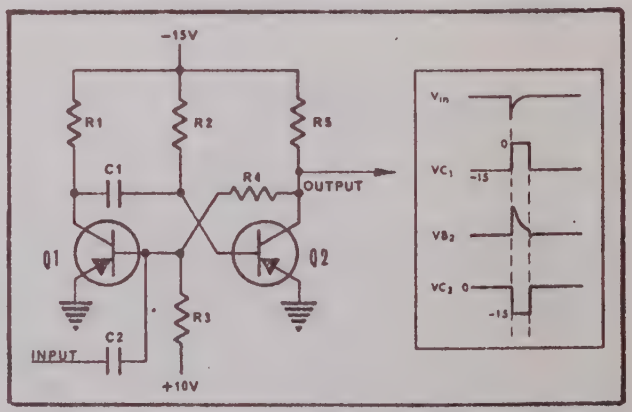


FIG. 3-25. Typical One-Shot Circuit.

The negative voltage at the collector of Q1 begins to swing positive. This positive transient is coupled to the base of transistor Q2, and forward bias on Q2 is decreased. Collector current of Q2 begins to decrease, and its collector voltage increases negatively. Part of this voltage is coupled through R4 to the base of Q1, increasing its negative potential. This regeneration results in a rapid change of both transistors; it drives Q1 into saturation and Q2 into cutoff. Since capacitor C1 was initially charged to -15 volts, the base of Q2 is at a positive potential of that magnitude (15 volts).

Capacitor C1 begins to discharge through R2 and the low resistance of Q1, and base potential of Q2 becomes less positive. When the base of Q2 becomes slightly negative, Q2 again conducts. Collector potential of Q2 increases positively and is coupled to the base of transistor Q1, driving it to cutoff. Transistor Q1 is again at cutoff and Q2 at saturation. This stable state is maintained until another negative pulse arrives to trigger the circuit.

3.9.5 Voltage Discriminator (Shaper)

The voltage discriminator (Schmitt trigger circuit), shown in Figure 3-26, differs from the binary in that one of the coupling networks is replaced by a common-emitter resistor. This arrangement provides additional regenerative feedback, thus obtaining a faster switching time.

The circuit can exist in either of two stable states: Q1 on, Q2 off, or Q1 off, Q2 on. Assuming that transistor Q1 is off, its collector voltage is at -15 volts. This negative voltage, coupled through R3, forward biases Q2 with a base potential of about -5 volts. Current flow from the emitter of transistor Q2 through R4 maintains the emitter of transistor Q1 at a negative potential. The reverse bias now developed between emitter and base of Q1 maintains the cutoff condition.

A negative-going input signal overcomes the reverse bias on the base of Q1 and it conducts. The collector potential of Q1 decreases (becomes less negative), and this transient is coupled to the base of Q2. Emitter current of Q2 decreases, lowering the potential across R4. The emitter of Q1 becomes less negative, reducing the reverse bias and increasing collector current. This regeneration continues until Q1 is saturated and Q2 is cut off.

This stable condition (Q1 on, Q2 off) continues until the input becomes more positive, at which time the reverse process takes place. The output of the Schmitt circuit is a square wave and does not depend upon the shape of the input waveform.

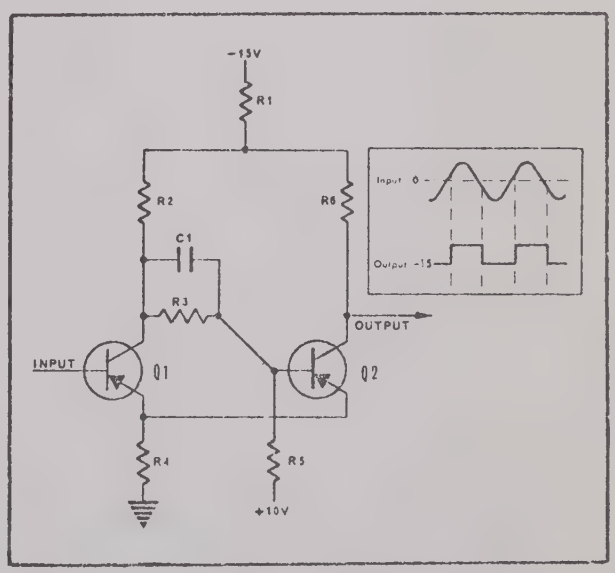


FIG. 3-26. Typical Voltage Discriminator.

SECTION 4
SERVICING

4.1 GENERAL

This section provides adjustment procedures and troubleshooting information for Model 6147. Additional maintenance data is covered in the appended DSU and DCU instruction manuals.

4.1.1 Required Test Equipment

Table 4-1 lists the recommended test instruments for servicing the counter. Other instruments may be used if their specifications meet or exceed the requirements listed.

Table 4-1. Test Equipment

Instrument	Required Specifications	Recommended Instrument
Oscilloscope	50 MHz bandwidth 3.5 ns rise time	Tektronix Model 581 with Type 80 and 82 Plug-ins
Signal Generator	1 Hz to 100 kHz 100 mV rms output	Accurate Instrument Corp. Model 5A51
Signal Generator	100 kHz to 25 MHz 100 mV rms output	Measurements Corp. Model 82
Volt-Ohmmeter	100,000 ohms/V dc	Simpson Model 269
Auto Transformer	0-130 V ac, 60 Hz	Variac Model W5MT3A
Freq. Comparator	1 MHz, 10 sec. count	RMS 9402
1 MHz Standard	*	House standard*
*Stability of 1 MHz reference must exceed stability of oscillator under test.		

4.1.2 Cabinet Removal

As shown in Figure 4-1, two screws at the rear of the instrument hold the top cover in place. After removing these screws, slide the top cover back and then upwards.

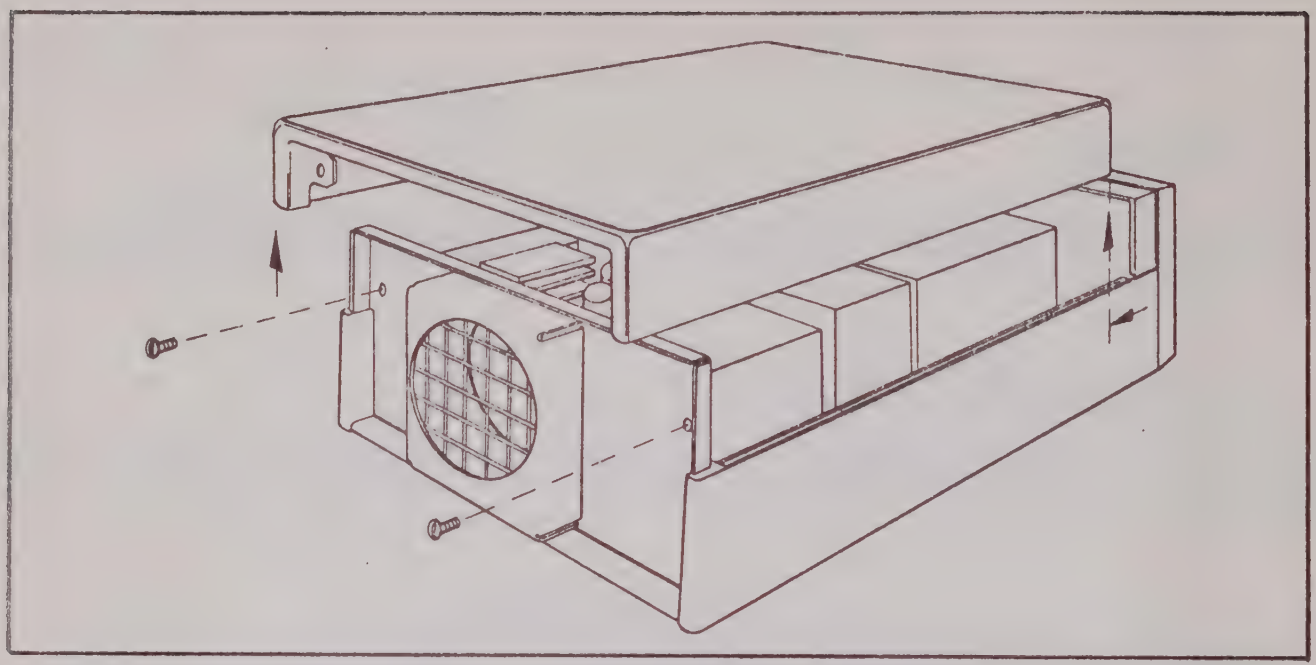


FIG. 4-1. Top Cover Removal.

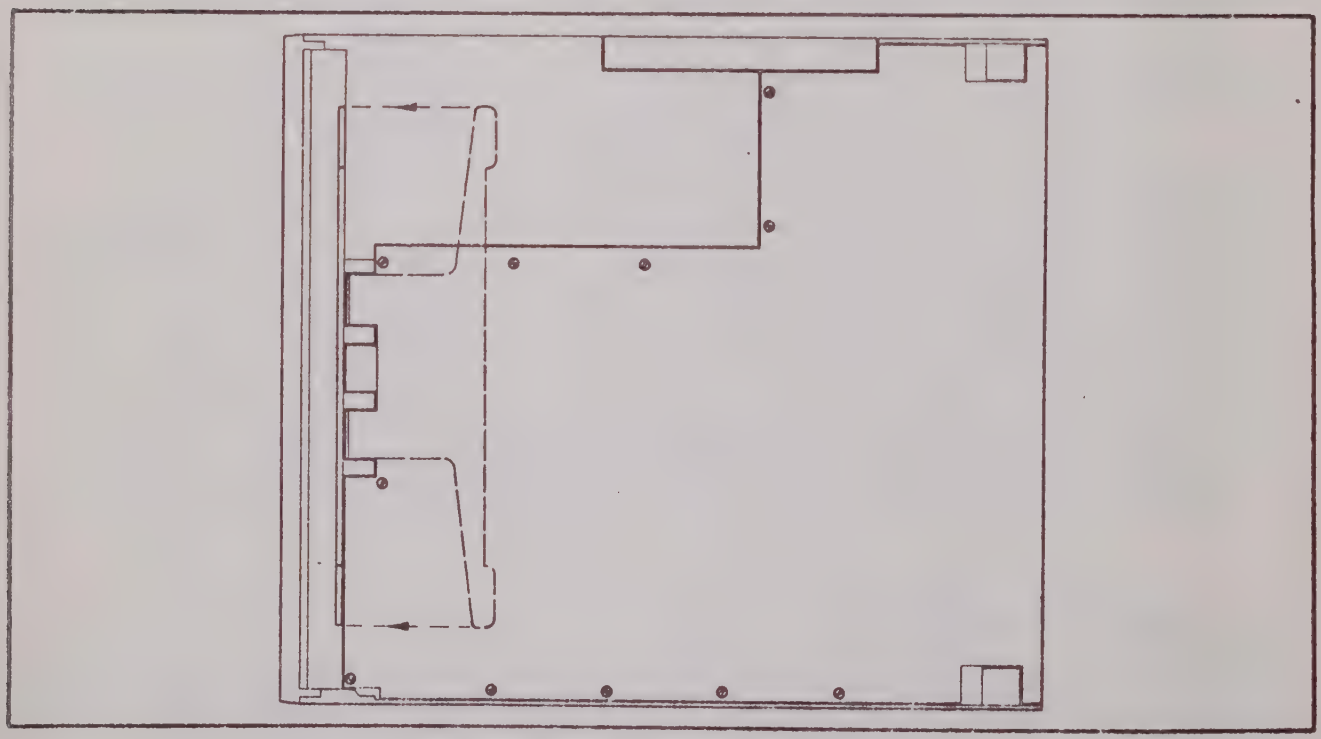


FIG. 4-2. Bottom Cover.

Figure 4-2 shows the screws that hold the bottom cover to the main chassis. When removing the bottom cover, turn the instrument upside down so the small spacers under the cover do not fall out when the screws are removed.

4.1.3 Printed Circuit Board Identification

Table 4-2 lists the printed circuit boards used in the instrument.

Table 4-2. Printed Circuit Board Identification

Printed Circuit Board Detail Number	Description	Printed Circuit Board Detail Number	Description
A1	Model 872 DCU	A17	Y Input Circuit
A2	Data Storage Unit	A18	X Input Circuit
A3	Model 862 DCU	A19 thru A24	Model 850 DCU
A4	Data Storage Unit		
A5	Model 860 DCU	A25	Model 860 DCU
A6	Data Storage Unit	A26	S Logic
A7	Model 850 DCU	A27	XY Logic
A8	Data Storage Unit	A28	Control
A9	Model 850 DCU	A29	M Logic
A10	Data Storage Unit	A30	Time Base Logic
A11	Model 850 DCU	A31	1-10MHz Multiplier
A12	Data Storage Unit	A32	Legend
A13	Model 850 DCU	A33	Recycle
A14	Data Storage Unit	A34	Regulator
A15	Model 850 DCU	A35	EL Supply
A16	Data Storage Unit		

4.1.4 Component Location

Location of assemblies is shown on the inside of the top cover. Figure 4-3 shows a detailed drawing of the Oscillator assembly. Components on printed circuit boards can be located using the appropriate printed circuit board layout drawing.

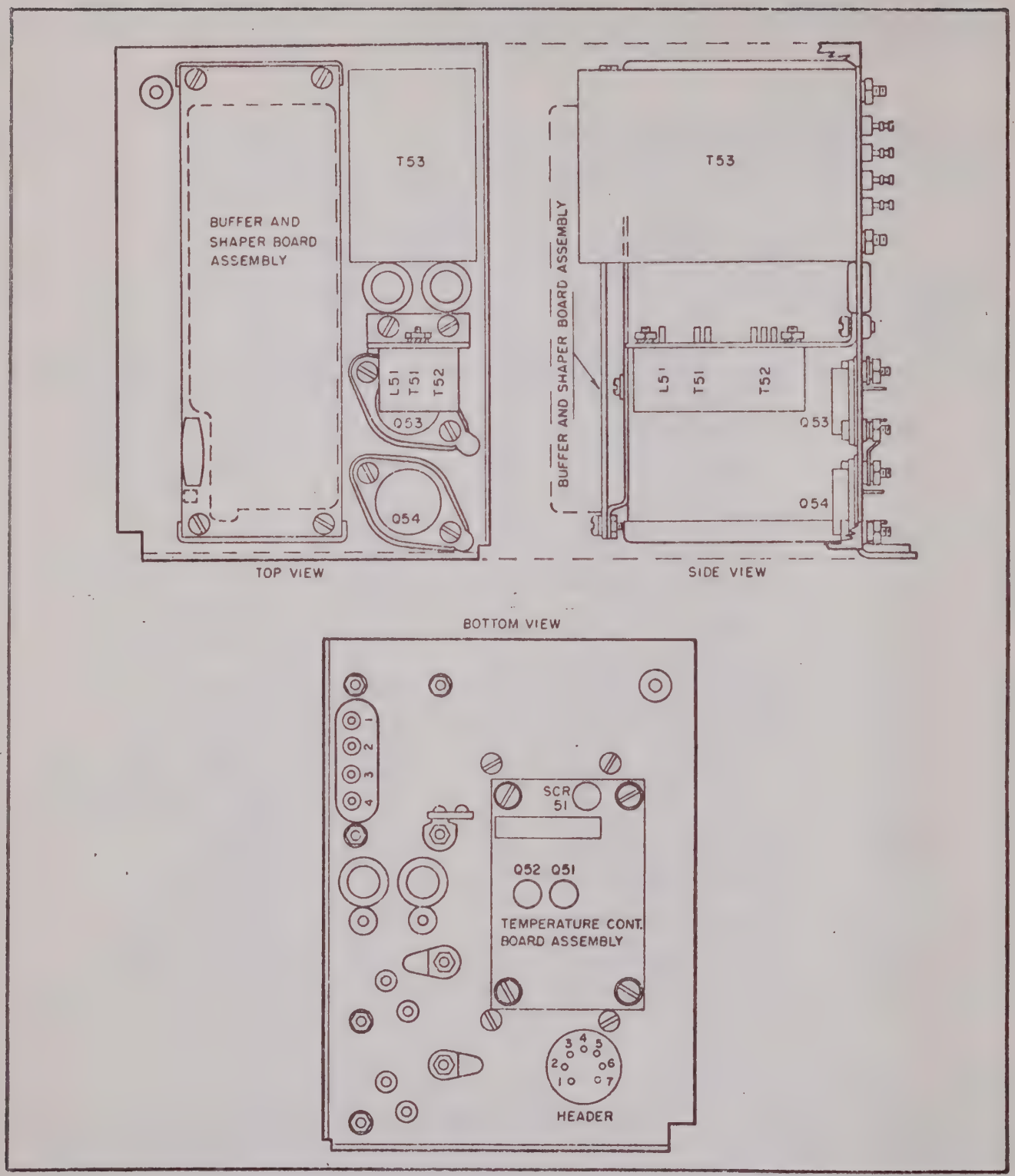


FIG. 4-3. Component Location -- Oscillator Assembly.

4.1.5 Extender Boards

Two extender boards have been supplied with the instrument to provide easy access to components and test points on printed circuit boards during operation. These boards are stored inside the Model 696 Basic Plug-In.

4.1.6 Plug-Ins

Unless other plug-ins are used, the Model 696 must be installed in the instrument for correct operation. A schematic diagram in the drawing section of the Model 6147 instruction manual shows the wiring of P6 in the Model 696. Instruction manuals are available for each of the other plug-in units.

4.2 ADJUSTMENTS

4.2.1 Power Supply Adjustments

The regulated power supply adjustments are located on the Regulator Board (A34 and the EL Supply Board (A35). The -15 V (R8, +15 V (R14), and +90 V (R21) adjustments are on A34. The +10 V adjustment (R4) is on A35. Figure 4-4 shows the location of these adjustments.

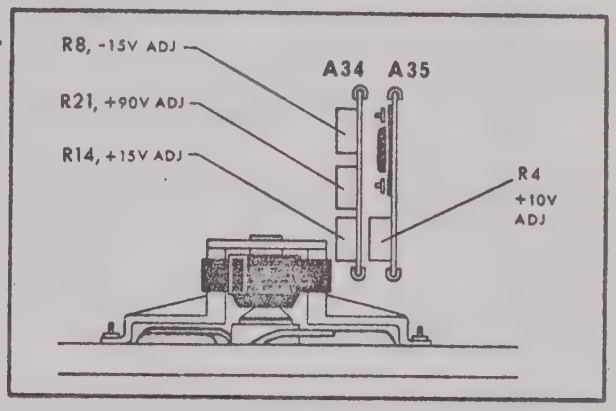


FIG. 4-4. Power Supply Adjustments.

4.2.1.1 Adjustment Procedure

CAUTION

Do not remove the Regulator Board (A34) from its receptacle without first unplugging the ac line cord from its power source.

1) Use a voltmeter of at least 0.01% accuracy. Voltage measurements are referenced to chassis ground.

2) Use Figure 4-5 to locate power supply test points.

3) Remove Regulator Board from its receptacle. Insert extension board into Regulator Board receptacle (XA34) and insert Regulator Board into extension board.

4) Adjust R14 for +15 volts, ±0.07 volt.

5) Adjust R8 for -15 volts, ±0.07 volt.

6) Adjust R21 for +90 volts, ±0.1 volt.

7) Unplug the ac line cord from its power source.

8) Remove extension board and return Regulator Board to its receptacle.

9) Remove EL Supply Board from its receptacle (XA35). Insert extension board into XA35 and insert EL Supply Board into extension board.

10) Adjust R4 for +10 volts, ±0.05 volt.

11) Return EL Supply Board to its receptacle.

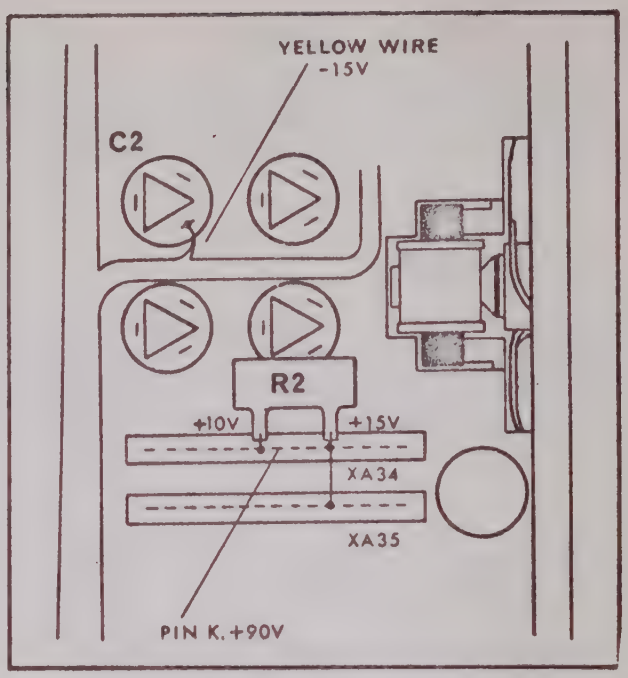


FIG. 4-5. Power Supply Test Points (Bottom View).

4.2.2 Oscillator Adjustments

Adjustment of the oscillator frequency is seldom required. When necessary, use one of the following procedures:

4.2.2.1 Lissajous Pattern Method

1) Use Figure 4-6 to locate oscillator adjustments C1 (FREQ ADJ) and R26 (FINE FREQ ADJ).

2) Use an oscilloscope of at least 10 megohms input impedance paralleled with approximately 15 pf; otherwise, loading may cause a shift in oscillator frequency.

3) Connect the oscillator output from FREQ connector J4 to the vertical input of the oscilloscope. (EXT-INT switch must be in INT position).

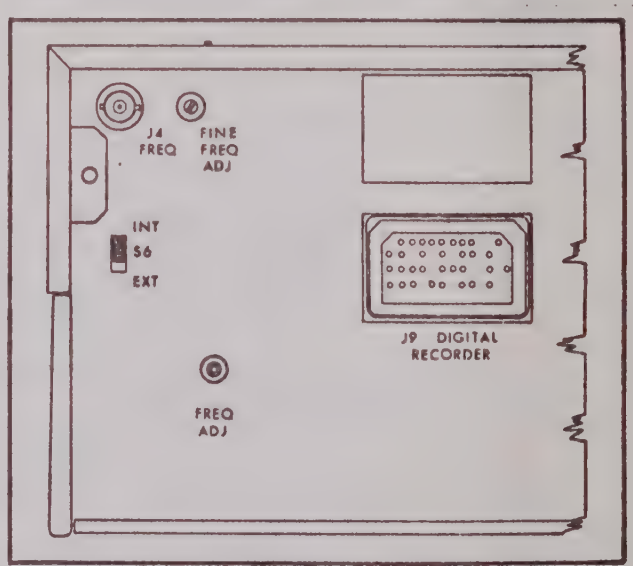


FIG. 4-6. Rear Panel Showing Oscillator Adjustments.

4) Couple a 1 MHz standard to the horizontal input of the oscilloscope and tune FREQ ADJ for a circular Lissajous pattern indicating equal frequencies.

5) If necessary, use FINE FREQ ADJ to tune oscillator to exactly 1 MHz.

4.2.2.2 Stabilized Scope Pattern Method

1) Use a Tektronix Model 543 (or equivalent) Oscilloscope. Set its time base to 0.1 microsecond; set its trigger control to External.

2) To its external trigger input, connect a 1 MHz standard signal; to its vertical input, connect the 1 MHz output signal from J4 (the FREQ connector) of the Model 6147.

3) Set the FINE FREQ ADJ on the counter to center of its range (13 turns from either end).

4) Adjust the FREQ ADJ on the counter until the oscilloscope displays a stable sine wave pattern.

5) Switch the Multiplier control on the oscilloscope to the X5 position (or higher if available); adjust the FINE FREQ ADJ to further stabilize the sine wave pattern.

4.2.2.3 Frequency Counter Method

For a more precise adjustment of the oscillator, use the following procedure:

1) Arrange the equipment as shown in Figure 4-7.

2) Connect the oscillator output from frequency connector S4 to the input of the frequency comparator.

3) Before attempting to calibrate the oscillator, set R26 (FINE FREQ ADJ) to the center of its range.

4) Adjustment of C1 (FREQ ADJ) is very coarse. Make this adjustment for a minimum reading on the frequency counter.

5) Tune R26 until the oscillator is properly adjusted.

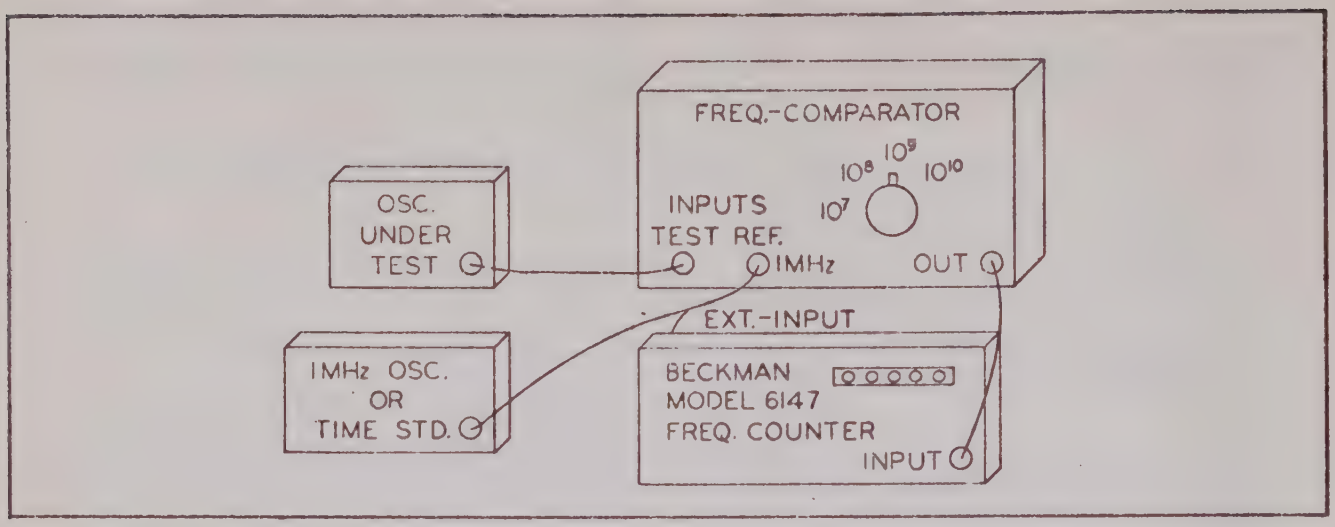


FIG. 4-7. Freq-Counter Method of Oscillator Adjustment.

4.2.3 Multiplier Adjustments

An incorrect reading in TEST may indicate that the 1-10 MHz multiplier is out of adjustment. See Table 2-6 in Section 2 for correct TEST readings. To adjust the multiplier, use this procedure:

1) Turn MODE selector to TEST and TIME selector to 1.0 μSEC.

2) Place oscilloscope probe on pin C of A31 (10 MHz output). See Figures 4-8 and 4-9.

3) With a non-metallic tuning wand adjust inductors L1 and L2 for maximum output at 10 MHz. Output should be at least 2.0 volts peak-to-peak.

NOTE

The 10 MHz signal will contain 1 MHz modulation of approximately 0.2 volt peak-to-peak.

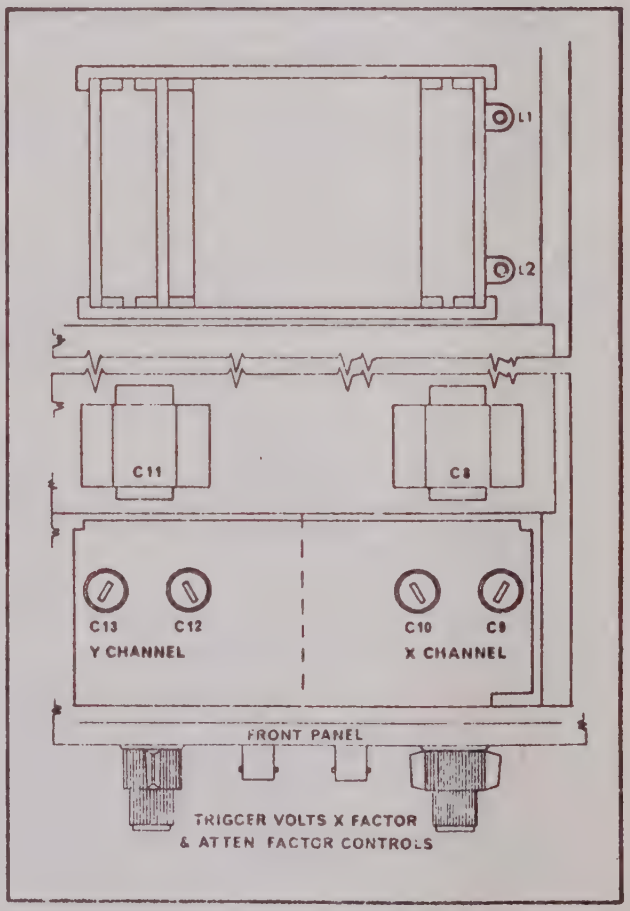


FIG. 4-8. Top View of Model 6146 Showing Multiplier and Attenuator Adjustments.

4.2.4 Attenuator Adjustments

If a component in the attenuator circuit is replaced, it may be necessary to readjust the trimmer capacitors to prevent distortion of the input signal. To adjust the attenuator, use this procedure:

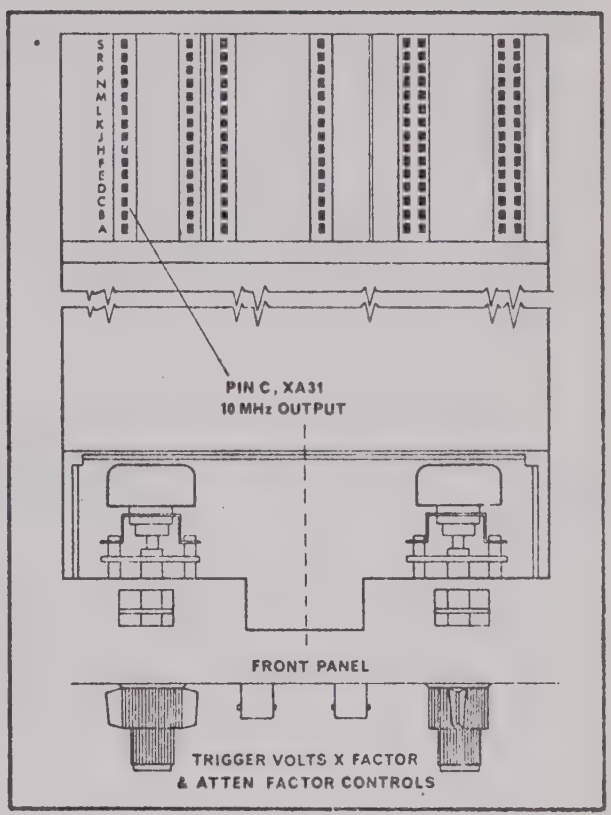


FIG. 4-9. Bottom View of Model 6146 Showing Multiplier Test Points.

1) See Figure 4-8 to locate adjustments.

2) Make sure amplifier boards are in place.

3) Set X ATTEN selector to AC 10. Apply a 2-volt peak-to-peak, 10kHz square-wave signal to INPUT X.

4) Place oscilloscope probe at pin A, XA18, to monitor output of the attenuator.

5) Adjust trimmer C9 for maximum flatness of the square wave.

6) Switch X ATTEN selector to AC100, and increase output of signal generator to 20 volts peak-to-peak.

7) Adjust trimmer C10 for maximum flatness of the square wave.

8) Set Y ATTEN selector to AC 10.

9) Apply a 2-volt peak-to-peak, 10kHz square-wave signal to INPUT Y.

10) Place oscilloscope probe at pin A, XA17, to monitor output of Y attenuator.

11) Adjust trimmer C12 for maximum flatness of the square wave.

12) Switch Y ATTEN selector to AC 100, and increase output of generator to 20 volts peak-to-peak. Adjust C13 for maximum flatness of the square wave.

4.3 TROUBLESHOOTING

4.3.1 General

Most circuits in the Model 6147 are mounted on printed circuit boards which can be removed and replaced easily. Troubleshooting is greatly simplified by replacing boards suspected of being faulty with spare boards which are known to be in good working order. Once the faulty board has been found, it can be repaired and returned to operation. Paragraph 4.3.3 describes how troubles may be isolated to an individual board (or boards).

4.3.2 Replacing Components on Printed Circuit Boards

To prevent damage to the printed circuit board and its components, use heat sparingly and work carefully. Follow this procedure for removing a defective component:

1) Melt the solder in the component lead holes and remove solder around component leads.

2) Straighten component leads with long-nose pliers or soldering aid.

3) Remove the defective component.

4) If component cannot be removed, reheat leads slightly.

To install a new component:

1) Clean lead holes thoroughly.

2) Cut and bend component leads to proper length and shape.

3) Insert leads through holes and solder into place.

NOTE

When installing transistors or diodes, use a heat sink to prevent excessive heat conduction through the component. Long-nose pliers applied between the component and the soldering iron make an effective heat sink.

4.3.3 Overall Troubleshooting

Troubles can often be isolated to an individual printed circuit board by observing front panel indications in the various operating modes. If the instrument is not functioning correctly, remove all input cable and set the MODE selector to TEST. Check all TIME selector positions for correct operation.

If the instrument functions correctly in TEST, but not in certain other modes the trouble may be in the input circuit, logic circuits, or possibly in the external signal source. Table 4-3 shows waveforms that should be obtained for four of the main operating modes. To isolate a trouble, switch the MODE selector to different positions, and monitor the waveforms at the points indicated. Waveform photographs are shown at the end of this section in Table 4-6.

The GATE OPEN light provides an additional visual indication of counter recycle. The light is on when the count gate is open, and off when the count gate is closed. If the instrument is operating in TEST—10SEC, the GATE OPEN light will be on for 10 seconds, and off for the length of time between measurements (determined by RECYCLE RATE setting). In PERIOD X modes, the light will flash at a uniform rate if amplifier triggering is correct.

For effective troubleshooting, the overall block diagrams should be used in conjunction with Table 4-3. For example, assume that the instrument is set to E/UT X mode and there is an acceptable count signal at A18, pin R, but no signal at A1, pin A. By referring to the block diagram it can be seen that the count signal must pass through an AND gate in the S Logic circuit before it is applied to the first counting DCU (Model 872).

Once a trouble has been isolated to an individual board, refer to the paragraph pertaining to that circuit for further troubleshooting information.

4.3.4 Input Circuit

If the instrument functions correctly in TEST, but fails in modes where an external input signal is being used, the trouble may be in the associated input amplifier or attenuator circuit. In the Model 6147, the X and Y amplifier boards are identical and can be interchanged to isolate the trouble.

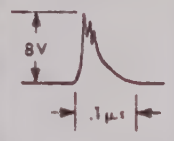
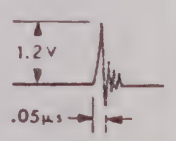
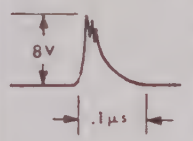
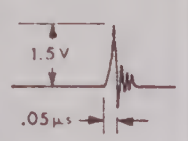
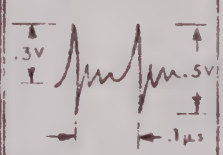
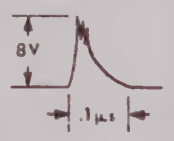
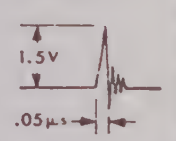
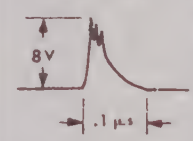
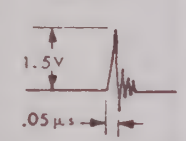
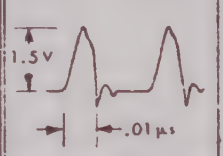
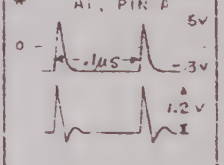
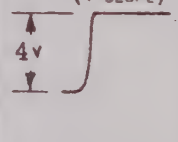
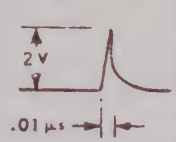
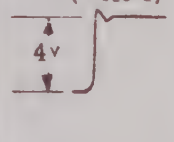
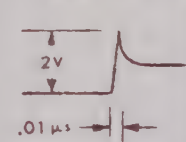
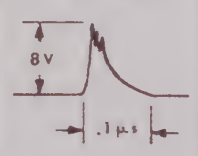
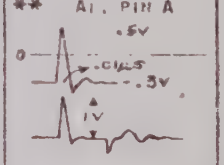
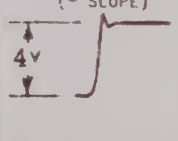
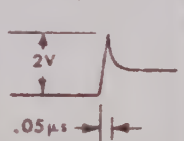
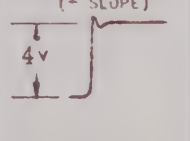
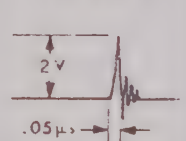
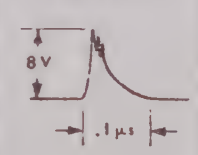
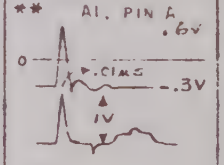
When it is certain that the amplifier board is defective, refer to Figure 4-10 to isolate the trouble further. Note that the Input Amplifier boards are covered by metal shields. These are removed in the same manner as a printed circuit board. If correct outputs are found at pins M, N, H, and R of the amplifier, but signals are not reaching their destinations, the trouble is probably in the S or XY Logic boards.

4.3.5 Time Base

Time base operation can be checked using the TEST mode. If readings are incorrect, use Figure 4-11 to isolate the trouble further.

In TEST, count pulses are derived from the 1-10 MHz Multiplier. If the Control circuits are gating correctly, but there is still no count (or an incorrect count), check the multiplier output (A31, pin C). Output should be 10 MHz, 2 volts peak-to-peak.

Table 4-3. Idealized Waveforms -- Four Operating Modes.

MODE & TIME SETTINGS	START SIGNAL		STOP SIGNAL		COUNT SIGNAL	
	SOURCE	CONTROL INPUT	SOURCE	CONTROL INPUT	SOURCE	CONTROL INPUT
TEST 1.0 μSEC	A30, PIN F 	A28, PIN A 	A30, PIN F 	A28, PIN C 	A31, PIN 1 	* A1, PIN A
E/UT 10 μSEC INPUT: 10 KHz, 100 mv rms	A30, PIN F 	A28, PIN A 	A30, PIN F 	A28, PIN C 	A18, PIN R 	* A1, PIN A 
1 PERIOD X 1 μSEC INPUT: 10 KHz, 100 mv rms	A18, PIN M (+ SLOPE) 	A28, PIN A 	A18, PIN M (+ SLOPE) 	A28, PIN C 	A30, PIN F 	** A1, PIN A 
TIM X-Y 1 μSEC X INPUT: 10 KHz, 100 mv rms Y INPUT: 10 KHz, 100 mv rms	A18, PIN M (- SLOPE) 	A28, PIN A 	A17, PIN N (- SLOPE) 	A28, PIN C 	A30, PIN F 	** A1, PIN A 

* For better scope indication, set TIME switch to 0.1 sec.

** For better scope indication, use 10 Hz at X and/or Y inputs.

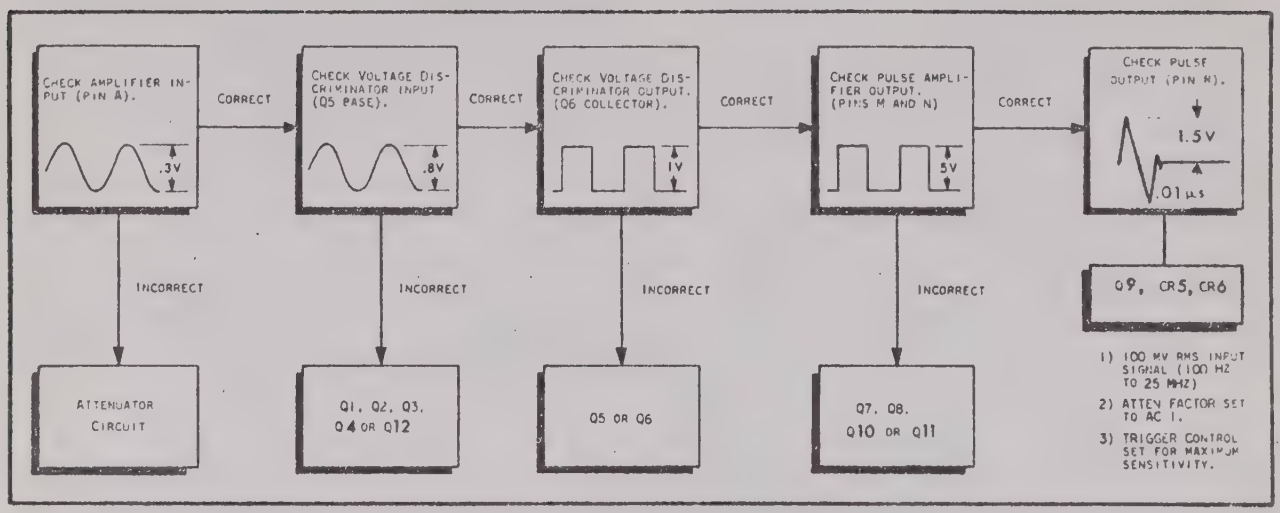


FIG. 4-10. Input Circuit -- Troubleshooting Guide.

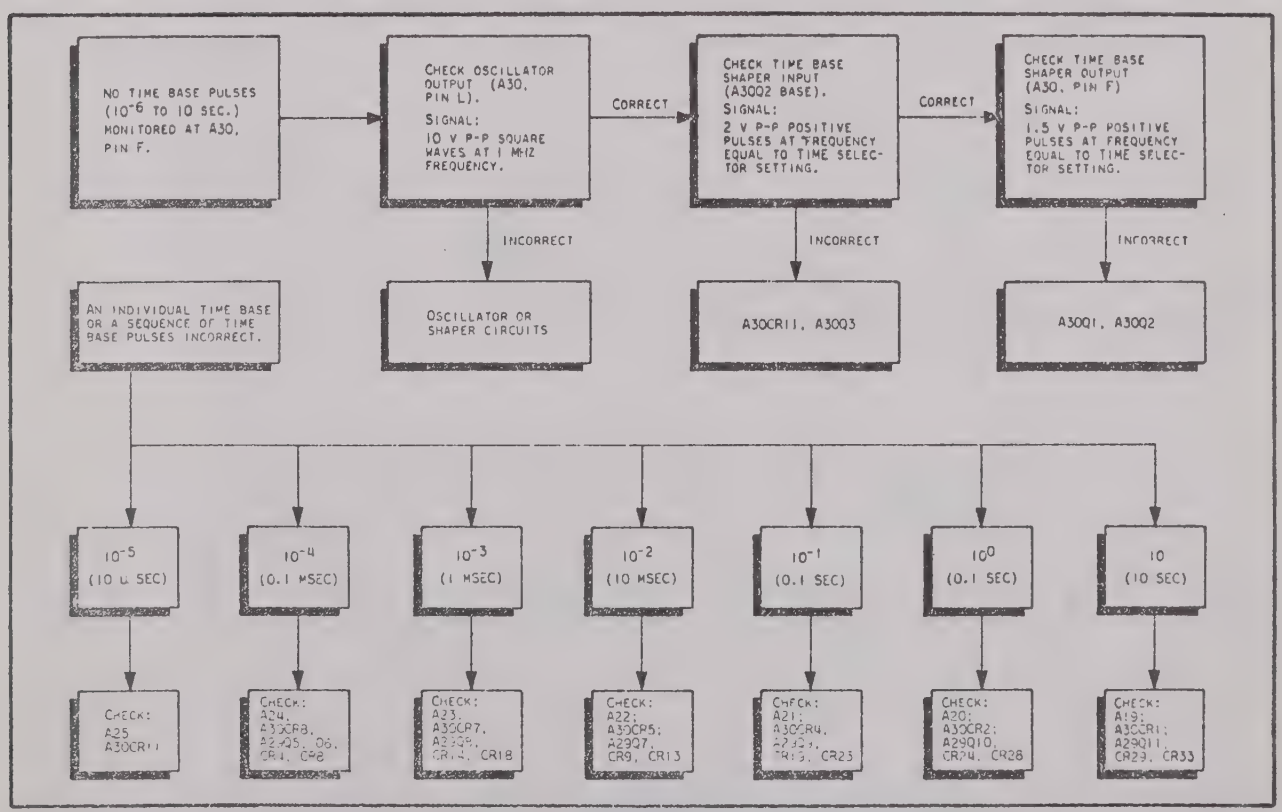

NO TIME BASE PULSES (10^{-6} TO 10 SEC.) MONITORED AT A30, PIN F.
CHECK OSCILLATOR OUTPUT (A30, PIN L).
SIGNAL:
10 V P-P SQUARE WAVES AT 1 MHZ FREQUENCY.
CORRECT
CHECK TIME BASE SHAPER INPUT (A30Q2 BASE).
SIGNAL:
2 V P-P POSITIVE PULSES AT FREQUENCY EQUAL TO TIME SELECTOR SETTING.
CORRECT
CHECK TIME BASE SHAPER OUTPUT (A30, PIN F)
SIGNAL:
1.5 V P-P POSITIVE PULSES AT FREQUENCY EQUAL TO TIME SELECTOR SETTING.
INCORRECT
INCORRECT
INCORRECT
AN INDIVIDUAL TIME BASE OR A SEQUENCE OF TIME BASE PULSES INCORRECT.
OSCILLATOR OR SHAPER CIRCUITS
A30CR11, A30Q3
A30Q1, A30Q2
10^{-5} (10 µ SEC)
10^{-4} (0.1 MSEC)
10^{-3} (1 MSEC)
10^{-2} (10 MSEC)
10^{-1} (0.1 SEC)
10^{0} (0.1 SEC)
10 (10 SEC)
CHECK: A25 A30CR11
CHECK: A24, A30CR8, A29Q5, Q6, CR4, CR8
CHECK: A23, A30CR7, A29Q9, CR14, CR18
CHECK: A22; A30CR5; A29Q7, CR9, CR13
CHECK: A21; A30CR4, A29Q8, CR19, CR23
CHECK: A20; A30CR2; A29Q10, CR24, CR28
CHECK: A19; A30CR1; A29Q11, CR29, CR33

FIG. 4-11. Time Base -- Troubleshooting Guide.

4.3.6 Power Supply

Regulation and maximum acceptable ripple for each of the dc power supply voltage are given in Table 4-4. The EL Supply output should be 900 volts p-p ±50 volts; frequency should be 500 Hz ±25 Hz. Frequency and voltage level of the EL Supply may vary widely before complete failure occurs. Use Figure 4-12 when troubleshooting the power supply.

Table 4-4. Power Supply Regulation

Power Supply Voltage	Regulation for 10% Line Change	Maximum Acceptable Ripple
+15	2%	10 mV p-p
+10	2%	10 mV p-p
-15	2%	10 mV p-p
+90	±1V	250 mV p-p

4.3.7 Legend

Table 4-5 shows legend and decimal placement for all possible combinations of MODE and TIME selector settings.

If one or more segments of the legend display fail to extinguish, check the +90 volt supply before checking the Legend Board itself. Neons and photoconductors are located under the cover of the Legend Board, and with the cover removed may be observed in operation.

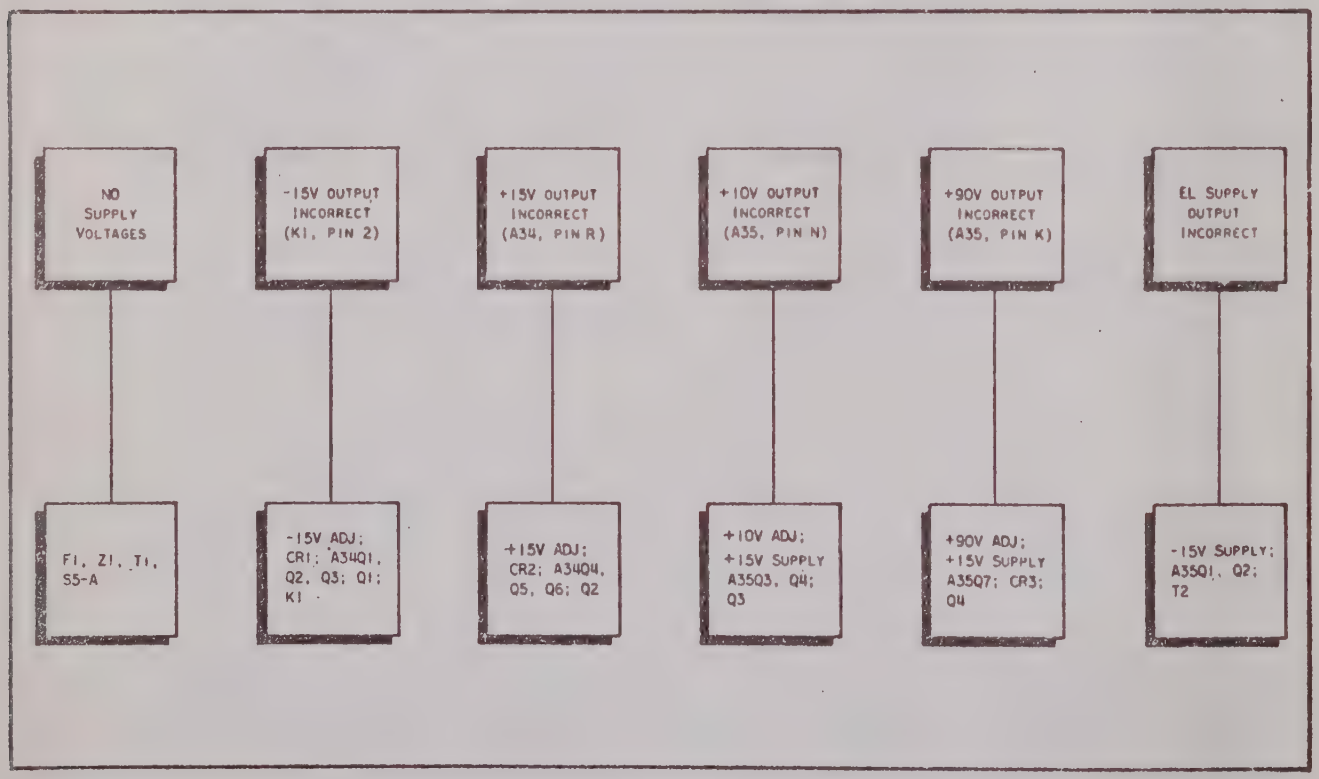

NO SUPPLY VOLTAGES
F1, Z1, T1, S5-A
-15V OUTPUT INCORRECT (K1, PIN 2)
-15V ADJ; CR1; A34Q1, Q2, Q3; Q1; K1
+15V OUTPUT INCORRECT (A34, PIN R)
+15V ADJ; CR2; A34Q4, Q5, Q6; Q2
+10V OUTPUT INCORRECT (A35, PIN N)
+10V ADJ; +15V SUPPLY A35Q3, Q4; Q3
+90V OUTPUT INCORRECT (A35, PIN K)
+90V ADJ; +15V SUPPLY A35Q7; CR3; Q4
EL SUPPLY OUTPUT INCORRECT
-15V SUPPLY; A35Q1, Q2; T2

FIG. 4-12. Power Supply -- Troubleshooting Guide.

WARNING

There are 900 volts p-p present on pin J of the Legend and DSU Boards. Therefore, unplug the ac line cord from its power source before removing or replacing these boards.

Table 4-5. Legend Nomenclature.

MODE SELECTOR

TIME SELECTOR	TEST	E/UT X	COUNT X	OFF	Y÷X	TIM X−Y	PER 1	10	10^2	10^3	10^4	10^5	10^6
10 SEC	KHz 5	KHz 5			1								
1.0 SEC	KHz 4	KHz 4			1	SEC 1	SEC 1	SEC 2					
0.1 SEC	KHz 3	KHz 3			1	SEC 2	SEC 2	SEC 3	SEC 4				
10 m SEC	KHz 2	KHz 2			1	SEC 3	SEC 3	SEC 4	SEC 5	SEC 6			
1.0 m SEC	MHz 4	MHz 4			1	mSEC 1	mSEC 1	mSEC 2	mSEC 3	mSEC 4	mSEC 5		
0.1 m SEC	MHz 3	MHz 3			1	mSEC 2	mSEC 2	mSEC 3	mSEC 4	mSEC 5	mSEC 6	mSEC 7	
10 µ SEC	MHz 2	MHz 2			1	mSEC 3	mSEC 3	mSEC 4	mSEC 5	mSEC 6	mSEC 7	mSEC 8	mSEC 9
1.0 µ SEC	MHz 1	MHz 1			1	µSEC 1	µSEC 1	µSEC 2	µSEC 3	µSEC 4	µSEC 5	µSEC 6	µSEC 7
0.1 µ SEC					1	µSEC 2	µSEC 2	µSEC 3	µSEC 4	µSEC 5	µSEC 6	µSEC 7	µSEC 8
INPUT Y					1		1	2	3	4	5	6	7

SEC — Legend
2 — Decimal Placement From Right
(The 9th Decimal Point Is Not Displayed)

Blank Space Indicates No Legend Or Decimal Point

Shaded Indicates Incompatible Combination Of Settings.

4.3.8 Recycle

Before servicing the Recycle Board, study the timing and block diagrams in Section 3 and observe operation of the instrument during FOLLOW and LATCH operation. Also, make sure that the Control Board is operating correctly.

When it is determined that the trouble might be in the Recycle circuits, refer to Figure 4-13 to aid in isolating the trouble to a particular stage.

4.3.9 Control

It is sometimes difficult to distinguish between Control and Recycle failures, since these circuits work together. To determine which assembly is at fault, use this procedure:

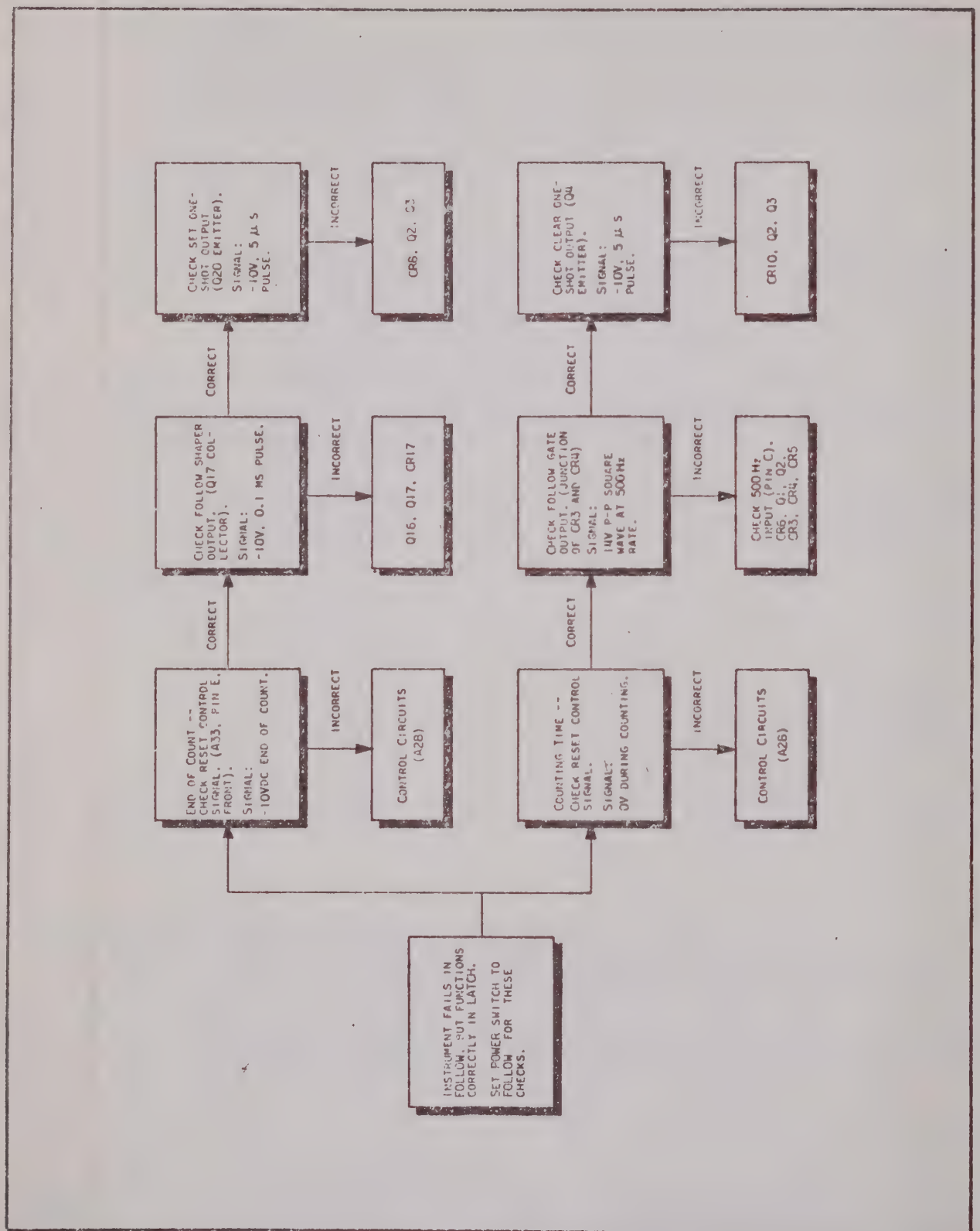

INSTRUMENT FAILS IN FOLLOW, BUT FUNCTIONS CORRECTLY IN LATCH.
SET POWER SWITCH TO FOLLOW FOR THESE CHECKS.
END OF COUNT -- CHECK RESET CONTROL SIGNAL. (A33, PIN E, FRONT).
SIGNAL: -10VDC END OF COUNT.
CORRECT
INCORRECT
CONTROL CIRCUITS (A28)
CHECK FOLLOW SHAPER OUTPUT. (Q17 COLLECTOR).
SIGNAL: -10V, 0.1 MS PULSE.
CORRECT
INCORRECT
Q16, Q17, CR17
CHECK SET ONE-SHOT OUTPUT (Q20 EMITTER).
SIGNAL: -10V, 5 µ S PULSE.
INCORRECT
CR6, Q2, Q3
COUNTING TIME -- CHECK RESET CONTROL SIGNAL.
SIGNAL: 0V DURING COUNTING.
CORRECT
INCORRECT
CONTROL CIRCUITS (A28)
CHECK FOLLOW GATE OUTPUT. (JUNCTION OF CR3 AND CR4)
SIGNAL: 1HV P-P SQUARE WAVE AT 500Hz RATE.
CORRECT
INCORRECT
CHECK 500 Hz INPUT (PIN C). CR6, Q1, Q2, CR3, CR4, CR5
CHECK CLEAR ONE-SHOT OUTPUT (Q4 EMITTER).
SIGNAL: -10V, 5 µ S PULSE.
INCORRECT
CR10, Q2, Q3

FIG. 4-13A. Recycle Circuit -- Troubleshooting Guide.

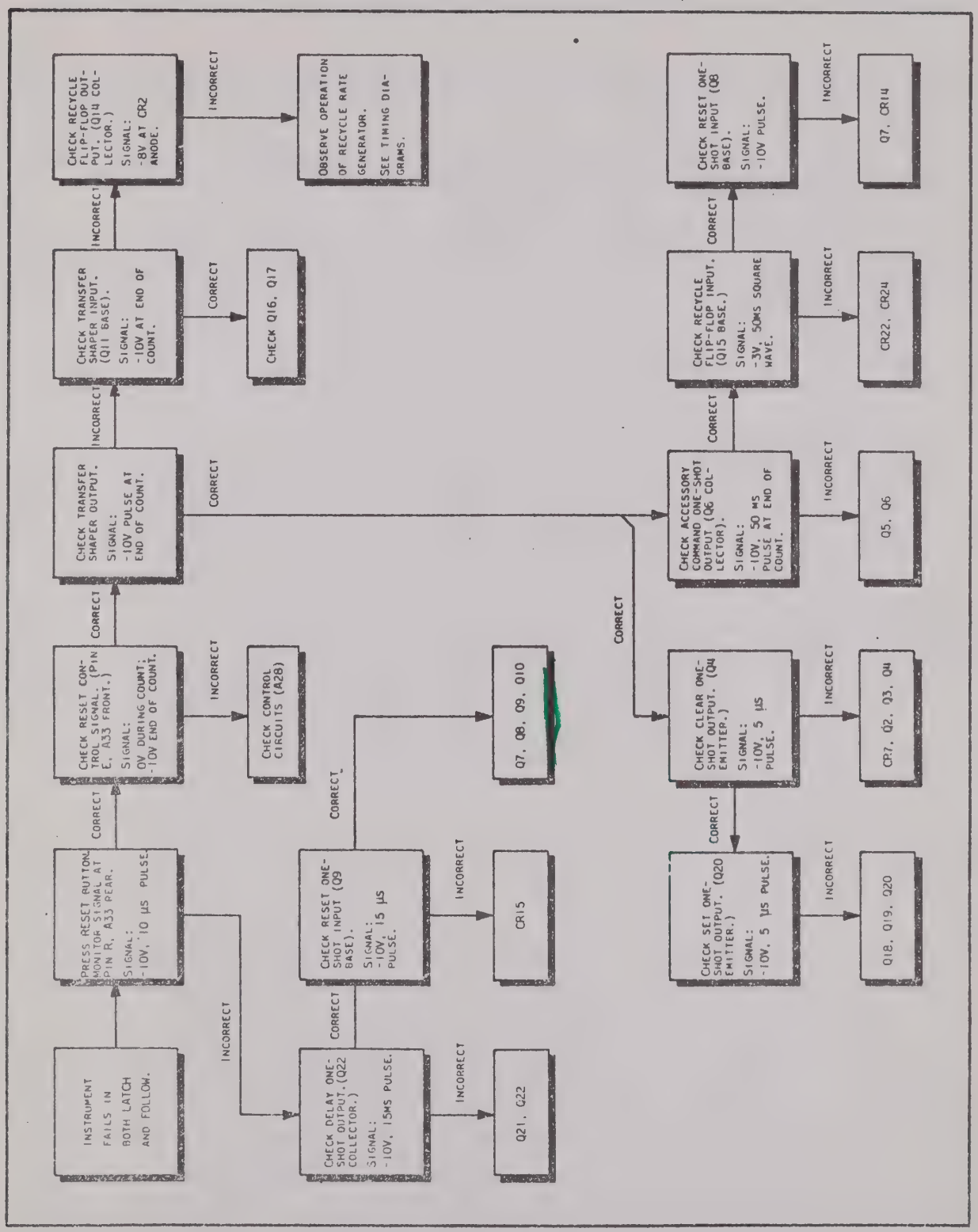

INSTRUMENT FAILS IN BOTH LATCH AND FOLLOW.
PRESS RESET BUTTON. MONITOR SIGNAL AT PIN R, A33 REAR. SIGNAL: -10V, 10 µS PULSE.
CHECK RESET CONTROL SIGNAL. (PIN E, A33 FRONT.) SIGNAL: 0V DURING COUNT; -10V END OF COUNT.
CHECK CONTROL CIRCUITS (A28)
CHECK TRANSFER SHAPER OUTPUT. SIGNAL: -10V PULSE AT END OF COUNT.
CHECK TRANSFER SHAPER INPUT. (Q11 BASE). SIGNAL: -10V AT END OF COUNT.
CHECK Q16, Q17
CHECK RECYCLE FLIP-FLOP OUTPUT. (Q14 COLLECTOR.) SIGNAL: -8V AT CR2 ANODE.
OBSERVE OPERATION OF RECYCLE RATE GENERATOR. SEE TIMING DIAGRAMS.
CHECK DELAY ONE-SHOT OUTPUT. (Q22 COLLECTOR.) SIGNAL: -10V, 15MS PULSE.
Q21, Q22
CHECK RESET ONE-SHOT INPUT (Q9 BASE). SIGNAL: -10V, 15 µS PULSE.
CR15
Q7, Q8, Q9, Q10
CHECK ACCESSORY COMMAND ONE-SHOT OUTPUT (Q6 COLLECTOR). SIGNAL: -10V, 50 MS PULSE AT END OF COUNT.
Q5, Q6
CHECK CLEAR ONE-SHOT OUTPUT. (Q4 EMITTER.) SIGNAL: -10V, 5 µS PULSE.
CR7, Q2, Q3, Q4
CHECK SET ONE-SHOT OUTPUT. (Q20 EMITTER.) SIGNAL: -10V, 5 µS PULSE.
Q18, Q19, Q20
CHECK RECYCLE FLIP-FLOP INPUT. (Q15 BASE.) SIGNAL: -3V, 50MS SQUARE WAVE.
CR22, CR24
CHECK RESET ONE-SHOT INPUT (Q8 BASE). SIGNAL: -10V PULSE.
Q7, CR14
CORRECT
INCORRECT

FIG. 4-13B. Recycle Circuit -- Troubleshooting Guide.

1) Set POWER switch to FOLLOW, MODE selector to TEST, TIME selector to 10SEC, and RECYCLE RATE control to MAN.

2) Press RESET button. Instrument should begin counting and GATE OPEN light should be on.

3) At the end of the 10 second timing interval, the instrument should stop counting and the GATE OPEN light should turn off.

If operation is incorrect, check for -10 volt pulse at A28, pin L, when the RESET button is pressed. Absence of the reset pulse indicates the trouble is probably in the Recycle circuits.

If the reset pulse at pin L is correct, use Figure 4-14 to troubleshoot the Control Board.

4.3.10 DCU's and DSU's

Servicing information for the DCU's and DSU's is included in the appended manuals.

4.3.11 Waveforms

Waveform photographs are shown in Table 4-6.

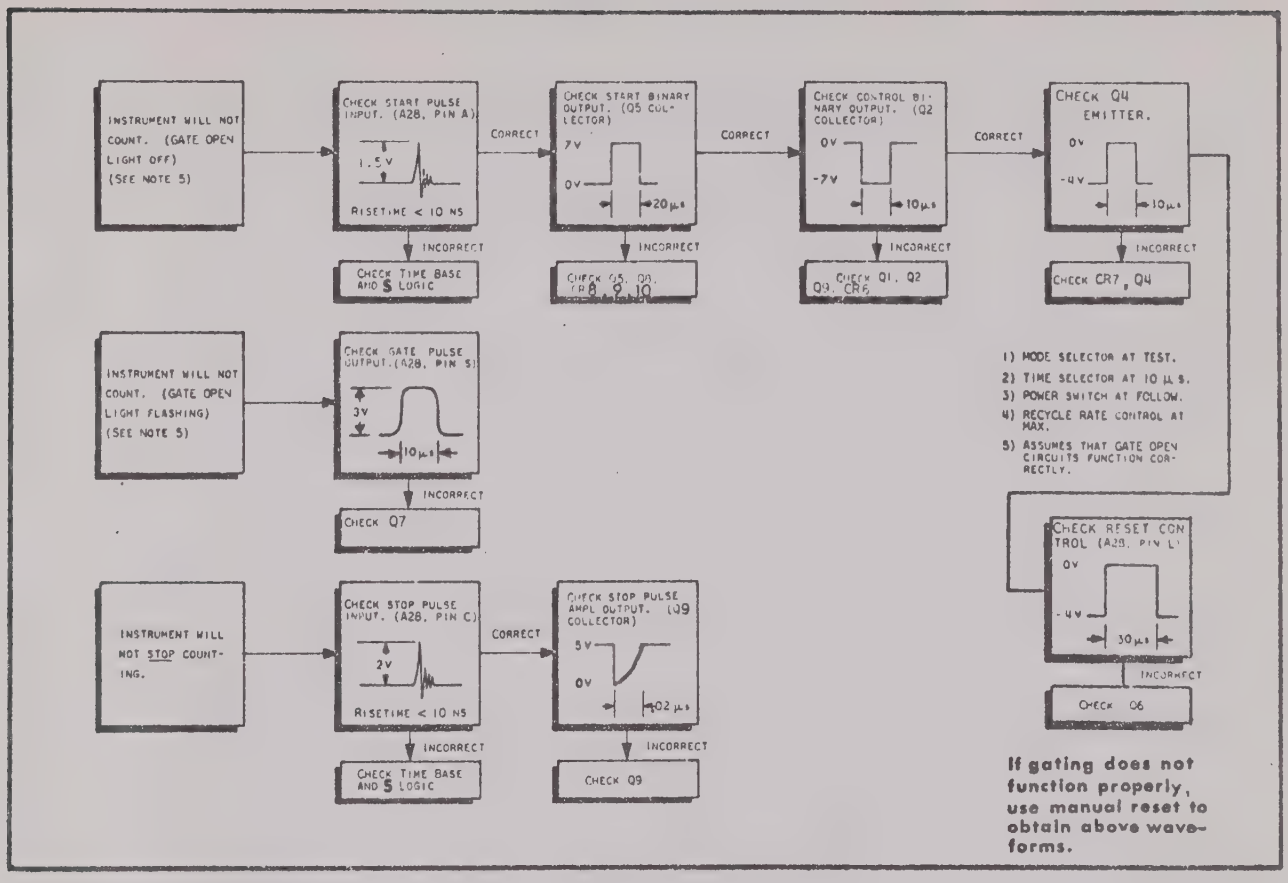
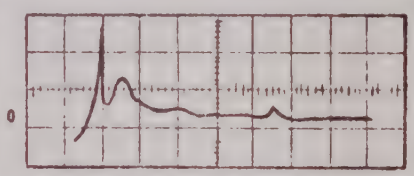
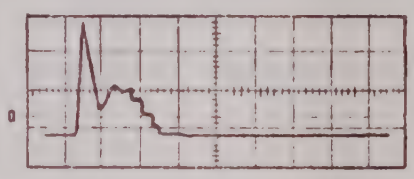
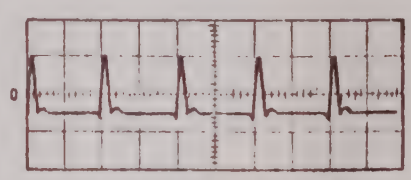
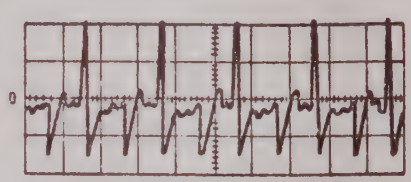
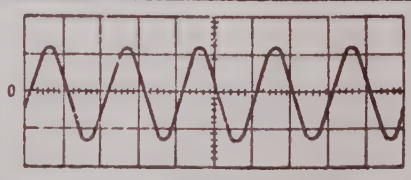


FIG. 4-14. Control Circuit -- Troubleshooting Guide.

Table 4-6. Waveforms.

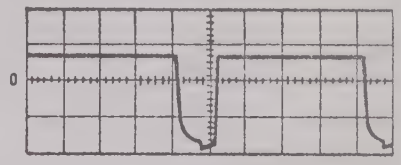
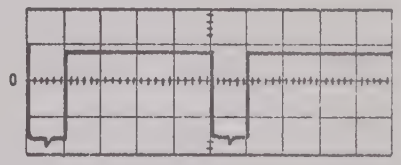
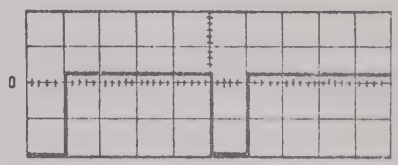
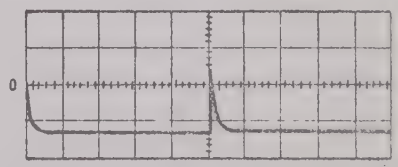
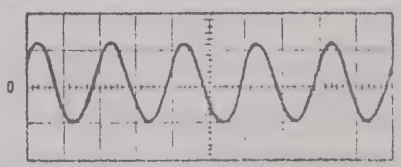
TEST CONDITIONS

Unit energized.
POWER switch to FOLLOW.
TIME switch to 10μs.
MODE switch to TEST.
RECYCLE RATE: Max.

TEST POINT	SIGNAL	VERT. V/Div.	HORIZ. Time/Div.	WAVEFORM
A28 Pin A	START Pulse	1 Volt (dc)	0.05μs	
A28 Pin C	STOP Pulse	1 Volt (dc)	0.05μs	
A 1 Pin A	COUNT Pulses In	0.5 Volt (dc)	0.05μs	
A31 Pin P	1 MHz Input	0.5 Volt (ac)	0.5μs	
A31 Pin C	10 MHz Output	1 Volt (dc)	0.05μs	

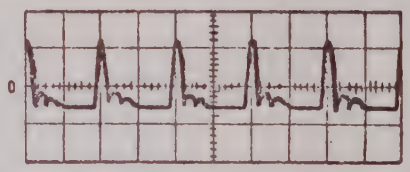
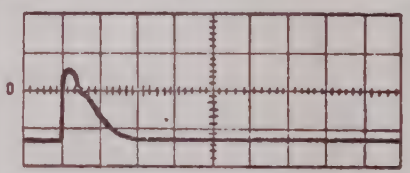
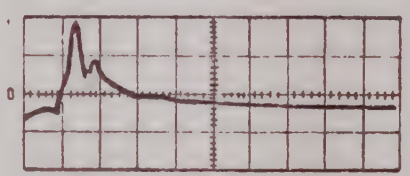
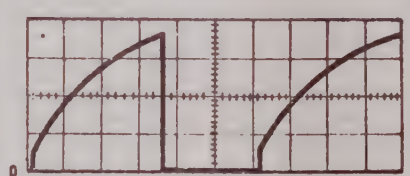
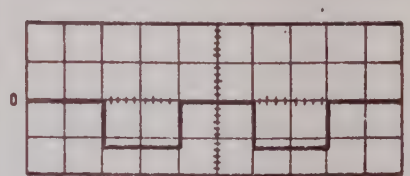
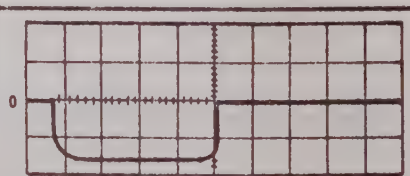
continued. . .

Table 4-6. Waveforms - continued.

TEST POINT	SIGNAL	VERT. V/Div.	HORIZ. Time/Div.	WAVEFORM
A30 Pin L	Oscillator Signal (10^{-6})	5 Volts (dc)	0.2μs	
A30 Pin P	A24 Output (10^{-4})	5 Volts (dc)	20μs	
A30 Pin 1	A23 Output (10^{-3})	5 Volts (dc)	0.2ms	
A30 Pin 4	A22 Output (10^{-2})	5 Volts (dc)	2ms	
A30 Pin F	Time Base Output	5 Volts (dc)	2μs	
A26 Pin C	COUNT Pulse Input	1 Volt (dc)	0.05μs	

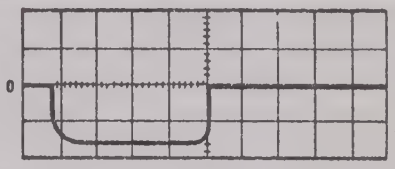
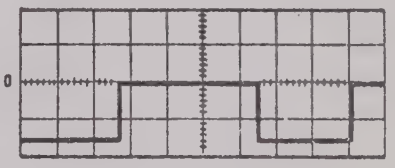
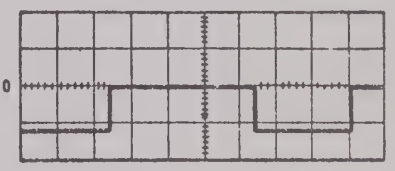
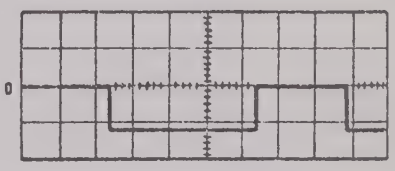
continued. . .

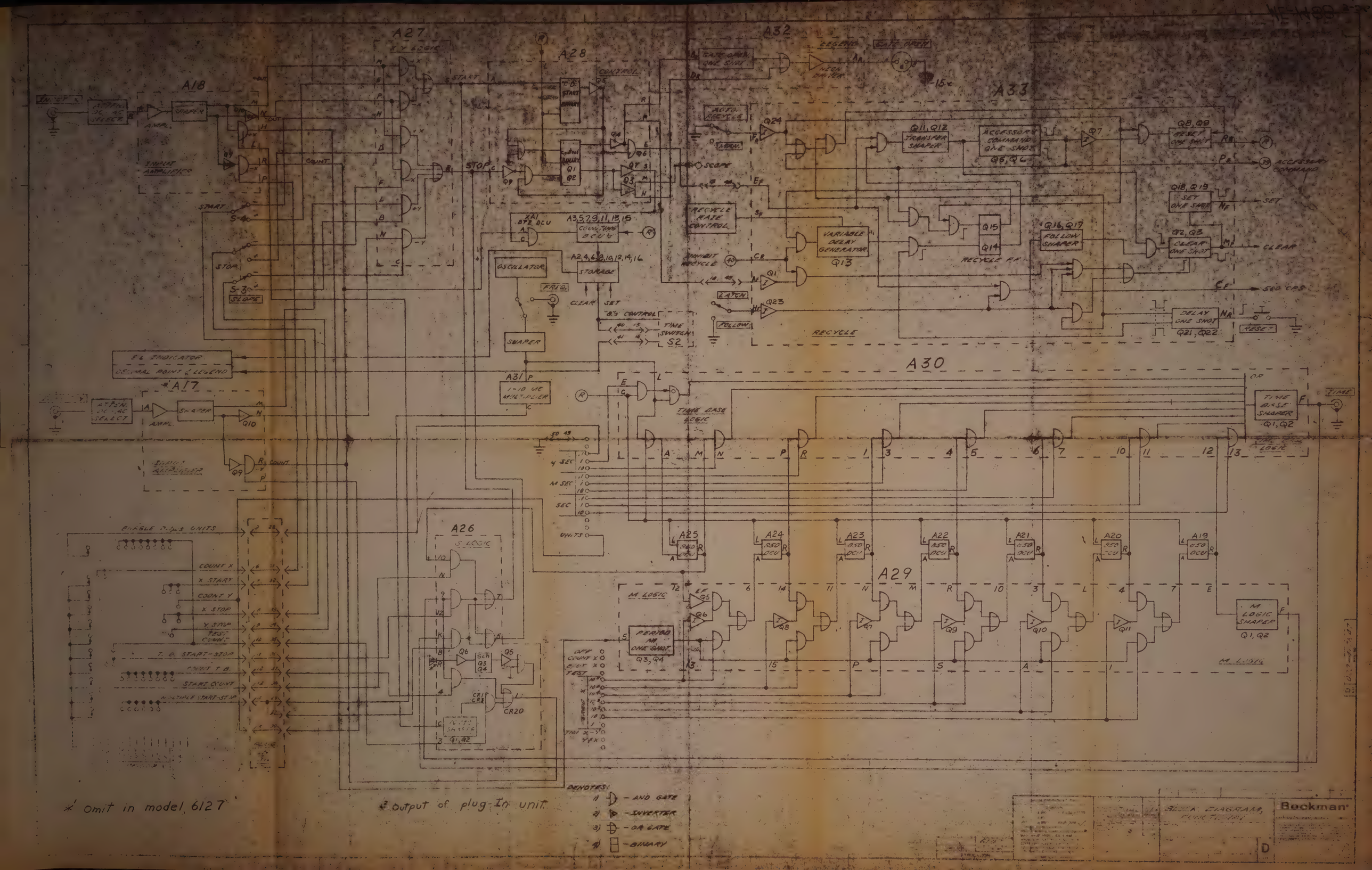
Table 4-6. Waveforms - continued

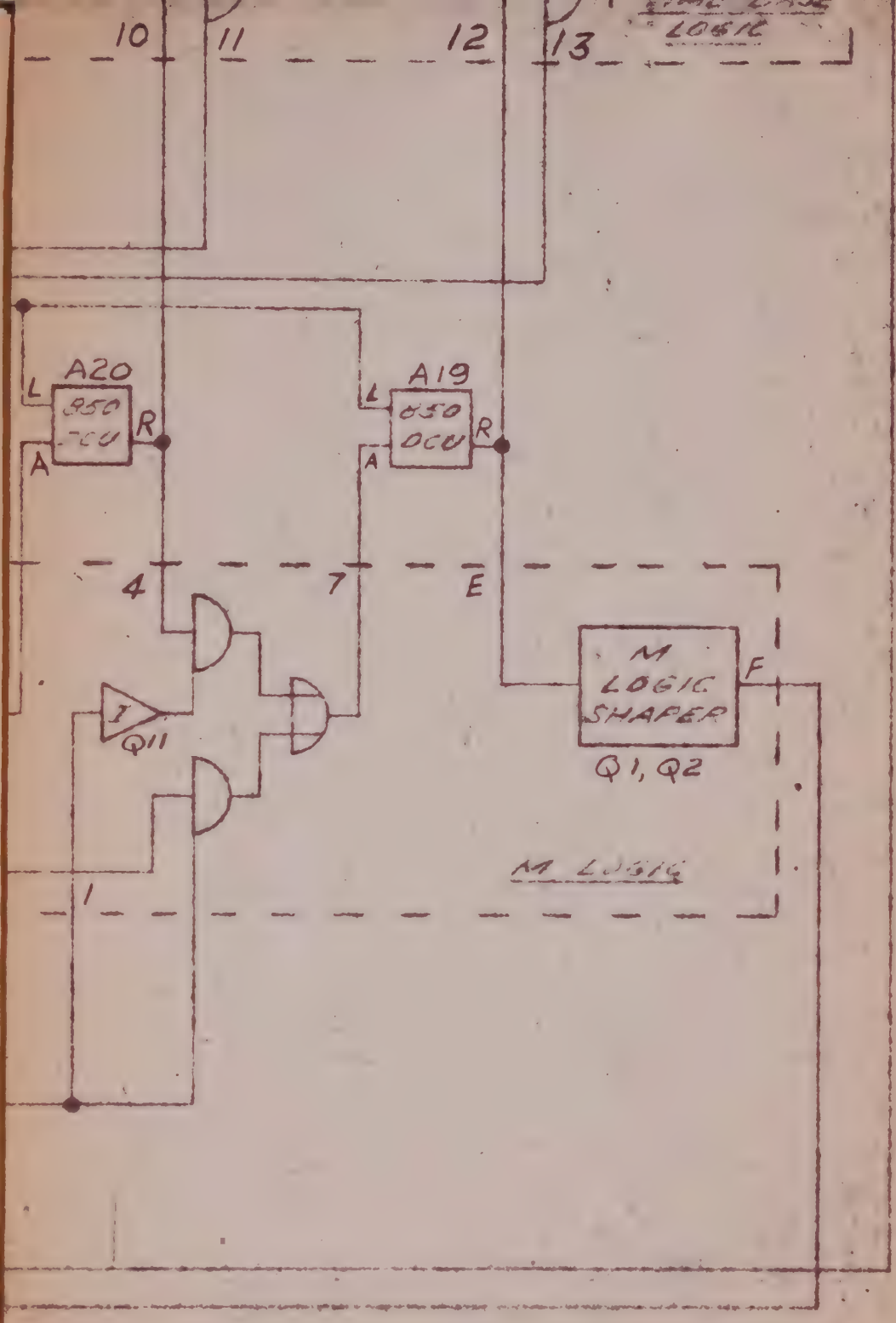
TEST POINT	SIGNAL	VERT. V/Div.	HORIZ. Time/Div.	WAVEFORM
A26 Pin 1	COUNT Pulse Output	0.5 Volt (dc)	0.05μs	
A26 Pin 9	START-STOP Pulses Input	5 Volts (dc)	0.05μs	
A26 Pin 7	START Pulse Output	1 Volt (dc)	0.05μs	
A33 Q13 Collector	Recycle Ramp	20 Volts (dc)	20ms	
A33 Pin C Front	500 Hz	20 Volts (dc)	0.5ms	
A33 Pin M Front	Clear One-Shot Output	5 Volts (dc)	1μs	

continued. . .

Table 4-6. Waveforms - continued.

TEST POINT	SIGNAL	VERT. V/Div.	HORIZ. Time/Div.	WAVEFORM
A33 Pin N Front	Set One-Shot Output	5 Volts (dc)	1 μs	
A33 Pin D Rear	Transfer Shaper Output	10 Volts (dc)	20ms	
A33 Q6 Collector	Print Command One-Shot Output	10 Volts (dc)	20ms	
A33 Q15 Collector	Recycle Control Signal	10 Volts (dc)	20ms	


A27
A28
A32
A33
A18
A30
A17
A31
A26
A25
A24
A23
A22
A21
A20
A19
A29
LEGEND
GATE OPEN
START
STOP
COUNT
RECYCLE
RECYCLE RATE CONTROL
VARIABLE DELAY GENERATOR
Q13
OSCILLATOR
STORAGE
TIME SWITCH
S2
TIME BASE LOGIC
TIME BASE SHAPER
Q1, Q2
M LOGIC
M LOGIC SHAPER
PERIOD 1/8 ONE SHOT
Q3, Q4
ACCESSORY COMMAND
ACCESSORY COMMAND ONE SHOT
Q5, Q6
RESET ONE SHOT
SET ONE SHOT
CLEAR ONE SHOT
FOLLOW SHAPER
DELAY ONE SHOT
Q21, Q22
RESET
SET
CLEAR
560 CPS
EL INDICATOR
DECIMAL POINT & LEGEND
ENABLE T.B.'S UNITS
COUNT X
X START
COUNT Y
X STOP
Y STOP
TEST COUNT
T. B. START-STOP
COUNT T.B.
START COUNT
MULTIPLE START-STOP
DENOTES:
1) - AND GATE
2) - INVERTER
3) - OR GATE
4) - BINARY
* Omit in model 6127
# Output of plug-in unit
Beckman
D



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